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SURVEY OF FISH IMPINGEMENT AT POWER PLANTS IN THE UNITED STATES

Volume II. INLAND WATERS

by

Richard F. Freeman III and Rajendra K. Sharma

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Environmental Control Technology
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ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue
Argonne, Illinois 60439

SURVEY OF FISH IMPINGEMENT AT POWER PLANTS IN THE UNITED STATES

(in four volumes)

Volume II. INLAND WATERS

by

Richard F. Freeman III
and
Rajendra K. Sharma

Division of
Environmental Impact Studies

March 1977

SURVEY OF FISH IMPINGEMENT AT POWER PLANTS IN THE UNITED STATES

PROJECT LEADER
Rajendra K. Sharma

Volume I.
THE GREAT LAKES

Volume II.
INLAND WATERS

Volume III.
ESTUARIES AND COASTAL WATERS

Volume IV.
COMPOSITE DATA EVALUATION

EDITOR
Richard B. Keener

PREFACE

Information on fish impingement at water-intake structures is being collected on a routine basis by a number of utilities, most specifically in accordance with the technical-specifications requirement of the U. S. Nuclear Regulatory Commission (USNRC) and/or the requirement of Public Law 92-500, Section 316(b), promulgated by the U. S. Environmental Protection Agency (USEPA). However, to date there has been no attempt to disseminate, on a national basis, the data and experience gained from these individual collection efforts. The purpose of this survey has been to compile much of this information in a series of reports that will aid in planning improvements in the siting, design, and operation of cooling-water intakes and that will be of use to the utilities' biologists and engineers, to environmental investigators and consultants, and to the regulatory agencies--principally USNRC and USEPA.

A fish-impingement study was initiated with funding from the U. S. Energy Research and Development Administration (USERDA), beginning in FY 1975, as the Lake Michigan Fish Impingement Study. The scope of this initial study was to identify major factors responsible for fish impingement at cooling-water intakes of power plants located on Lake Michigan. Efforts to gather sufficient information for our data analysis were largely unsuccessful; data on the variables which could affect fish impingement were not available for most of the plants. The abundance and distribution of fish species in the water body in the vicinity of the site concurrent with the determination of fish impingement at intake screens were important parameters for our analysis, but this information was never adequate. Therefore, a meaningful analysis and interpretation to satisfy our original objective could not be made. Beginning in FY 1976, USNRC funded a survey of the fish-impingement problem in an endeavor to bring together fish-impingement data on a national basis. We considered it appropriate to merge these two projects to provide a more comprehensive presentation of information regarding fish impingement.

The survey has resulted in a four-volume series. Volume I covers power plants located on the Great Lakes, with emphasis on Lake Michigan. Volume II deals with power plants located on inland waters other than the Great Lakes, with emphasis on the Tennessee River and the Tennessee Valley Authority system. Volume III covers power plants located on estuaries and coastal waters. Volume IV in this series deals with composite data evaluation, and highlights interplant comparisons among and within various ecosystems.

Comments are welcome, especially from the utilities whose data we have used, and may be directed to me.

Rajendra K. Sharma, Project Leader
Division of Environmental Impact Studies
Argonne National Laboratory
Argonne, Illinois 60439

ACKNOWLEDGMENTS

Acknowledgments are extended to the following:

- The funding agencies--USERDA and USNRC;
- The utilities whose data we have used in this study and are too numerous to list here;
- The regional USEPA offices, especially Regions I, IV, and V, who provided information that we could not procure directly from the utilities;
- I. P. Murarka and J. V. Tokar (ANL), who participated in an early phase (FY 1975) of the Lake Michigan Fish Impingement Study; and
- Those staff members of the Division of Environmental Impact Studies who from time to time were assigned to assist in the study.

CONTENTS - VOLUME II

SURVEY OF FISH IMPINGEMENT AT POWER PLANTS IN THE UNITED STATES

Volume II. INLAND WATERS

Richard F. Freeman III and Rajendra K. Sharma

Abstract

Impingement of fish at cooling-water intakes of 33 power plants located on inland waters other than the Great Lakes has been surveyed and data are presented. Descriptions of site, plant, and intake design and operation are provided. Reports in this volume summarize impingement data for individual plants in tabular and histogram formats. Information was available from differing sources such as the utilities themselves, public documents, regulatory agencies, and others. Thus, the extent of detail in the reports varies greatly from plant to plant. Histogram preparation involved an extrapolation procedure that has inadequacies. The reader is cautioned in the use of information presented in this volume to determine intake-design acceptability or intensity of impacts on ecosystems. No conclusions are presented herein; data comparisons are made in Volume IV.

INTRODUCTION

Loss of fish at water-intake screens has been identified as one of the major impacts on aquatic biota resulting from operation of thermal power plants. Water used for condenser cooling must be screened of debris and aquatic biota to protect pumps and to prevent clogging of condenser tubes. Usually the water is screened through traveling screens having 3/8-inch-square mesh. The unidirectional flow of water into the intake results in accumulation of fish and debris on the screens. When screens are cleaned, fish and debris are washed off and are disposed of on land or returned to the source water body. Of those fish returned to the water, survival varies depending on design and operation of screening and fish-return systems. Generally, survival is low and can be assumed to be nil for most water intakes.

Impingement of fish is an unavoidable result of the screening of water taken from water bodies inhabited by fish. The problem has existed ever since water has been screened for irrigation and municipal, industrial, or other purposes. However, the focus on the issue has sharpened because of environmental awareness and because of the increase in cooling-water requirements at individual power plants, resulting in noticeable losses and public attention. The "Federal Water Pollution Control Act Amendments of 1972" (Public Law 92-500), administered by the U. S. Environmental Protection Agency (USEPA), requires under the provisions of Section 316(b) that the "... location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact." Nuclear power plants are regulated by the U. S. Nuclear Regulatory Commission and their operation is conditioned by Environmental Technical Specifications. These specifications and administration of P.L. 92-500, Section 316(b) usually require collection of fish-impingement information so that the magnitude of the problem may be assessed and mitigative actions may be implemented where warranted. This information is collected and assessed on an individual-plant basis, and little or no flow of information regarding acquired data and experience passes between utilities and agencies concerned with the issue. Inasmuch as accurate predictions of the magnitude of impingement and the significance of such losses on aquatic biota may never be possible, dissemination of such information will play a significant role in providing insight into the problem and in providing bases for impact assessment and implementation of mitigative measures.

This study was designed to survey and catalog fish-impingement and related information available on various power plants in the United States. In order to limit the scope of the survey to a manageable project, information was sought on fossil power plants of 500 MWe or larger and on all nuclear power plants; however, wherever available, information on smaller fossil plants was included. In order to provide an allowance for similarity of impacts in a given ecosystem, the information was divided into three categories, each covered in a separate volume of the survey. This volume covers power plants located on inland waters other than the Great Lakes, with emphasis on the Tennessee River and the Tennessee Valley Authority system. Other volumes deal with plants on the Great Lakes and on estuaries and coastal waters.

A letter (Fig. 1) explaining the survey, together with a request for specific information (Fig. 2), was sent to all power companies that operate nuclear plants and operate fossil plants 500 MWe or larger in capacity. For information, copies were sent to the Regional Administrators of the ten regional offices of the USEPA. Where available, information was also retrieved from reports on fish impingement filed with the U. S. Nuclear Regulatory Commission. Although information on the nuclear power plants has been readily forthcoming, utilities were considerably reluctant to release information on fossil power plants prior to meeting 316(b) requirements. Therefore, the USEPA was asked to provide us with pertinent information where possible. We were unable to procure information on several plants because the 316(b) studies had not been completed or even initiated.

The status of 316(b) studies for all nuclear plants and fossil plants over 500 MWe is given in Table I. This table was compiled using information gathered from telephone conversations, letters from the utilities, and other sources as indicated. The table covers 296 plants with a total generating capacity of 291.59 GWe, representing 80% of the 364.35 GWe generated in 1974 by thermal power plants in the United States.[1]

We have not undertaken nor do we recommend a sophisticated analysis of the data in this survey on an individual-plant basis. Fish-impingement data alone provide no basis for decisions on intake technology nor are they appropriate for determining significance of impacts. Volume IV in this series is intended to provide perspective on fish-impingement data by making interplant comparisons within and among various ecosystems. This effort does not employ sophisticated analyses; rather it is meant to portray the variability and presence or absence of trends in the information we have processed.

Maps showing the locations of plants reported on in this volume are shown in Figures 3 and 4. An index of common names of all fishes referred to in this volume is given in Table II. It provides the scientific name of each fish, using a publication of the American Fisheries Society as authority.[2]

Information on each of the plants has been organized and presented in a standardized format. Individual plant reports vary in depth and extent of coverage depending on available information. Inasmuch as the volume of information and details that we obtained varied greatly, we used our discretion in selecting information that we thought was directly related to the problem of fish impingement. A brief description of the seven headings in the standardized format follows. Text is followed by references, figures, tables, and histograms as appropriate.

SITE CHARACTERISTICS

The plant location is described. Physical, chemical, and biological characteristics of the water body at the site are briefly described. Annual water-temperature range, flow rates or water currents past the site, water movement and turnover rates, dissolved oxygen, pH, salinity levels, and presence of dams or other structures upstream or downstream are described if information was available. Brief descriptions of fish fauna and seasonal distribution and abundance are given for some of the sites. A list of fish species captured in the vicinity of the site or impinged on the intake screens has usually been available. Reference to fishes in the individual plant reports is by common name only; scientific names can be noted by referring to the index provided in this introduction (Table II).

PLANT DESCRIPTION

Plant capacity is given in MWe. It is indicated whether the plant is nuclear or fossil and whether it is operated with a once-through or a closed-cycle cooling system. Also, the letter N or F in the title of each report denotes nuclear or fossil fuel, respectively. The designation of plant or station conforms to usage employed by the utility, if that usage was apparent.

INTAKE DESIGN AND OPERATION

When available, figures are included to show the overall site layout and location of intake with respect to the physical features of the site and the water body, a layout of the cooling system from intake to discharge, a close-in diagram of the intake forebay and pumps with details of such structures as the trash racks, deicing loops, traveling screens, screen-backwash systems, etc. When appropriate, figures of offshore intakes and special screening systems are also included. Intake design is described from the outermost trash racks or bars to the pumps. The intake operation is described in terms of flow rates, design or measured intake velocity at various points in the intake system, screen rotation and frequency of screen washing, sluice system and ultimate disposal of fish and debris, and operation of the deicing loop to prevent freezing of screens in winter.

IMPINGEMENT SAMPLING

There are large variations in methods of monitoring or sampling of fish impingement at intake screens. At some plants 24-hour collections are made every day, whereas at others sampling is performed for only a few hours during a month. When collections are large, a subsampling scheme is usually employed to estimate total impingement. There is a large variation in the type and amount of information recorded from these monitoring programs. The information may include size, weight, gonadal condition, sex identification, scale sample, and other parameters by species, or may include only numbers by major groups.

DATA AVAILABILITY

Only those dates for the data made available to us are given. It is conceivable that data for time periods in addition to those listed are available.

IMPINGEMENT DATA SUMMARY

Generally, data were available to us for each of the samples by species and numbers of each of the species. Important species (based on abundance) were identified for each of the sites, and data were processed for each of the samples to list numbers of important species individually and the total for all species including the important species. In order to present information on a uniform basis we selected a yearly histogram format. Simple proportional extrapolations were made to obtain daily and monthly estimates for each of the important species and the total for all species. These estimates were then plotted in a yearly histogram. The actual time period for sampling varied greatly from plant to plant and from month to month, and the fractional number at the bottom of each bar of the histogram indicates the number of days sampled per month. Thus, the original number of fish impinged during a sampling period can be readily back calculated. Absence of a number at the bottom of the histogram indicates that no sampling was done during that month. Absence of a histogram bar for a month when sampling is indicated by a fractional number indicates that sampling was conducted but no fish were captured from the screens. In all extrapolations full-time operation of the station was assumed. We feel that no extrapolation scheme, no matter how sophisticated, can accommodate all of the vagaries of sampling schemes. In our opinion, simple extrapolation at least provides an opportunity to back calculate the original number impinged for a given sampling period.

When information was available for more than one year, an effort was made to plot histograms for a given species on the same page, thus providing easy comparison of annual fluctuations and seasonal trends. The impingement numbers are plotted on a logarithmic scale. There are scale changes from report to report, and sometimes within a report, depending on the number of fish killed. Thus, caution should be exercised in comparing heights of the bars; the vertical scale must be observed.

A summary table of fish impingement data is presented in each report. It contains information on the total number of fish impinged, and the number of fish of important species impinged, estimated for the number of months the sampling was conducted in a given year. Note that these estimates do not represent the number of fish killed per year; rather they indicate the estimated number of fish killed during the months the sampling was done.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

Wherever used, devices such as air-bubble curtains, electric screens, reduction in intake velocity, and others are described and their success as reported by the utility or as described by other sources is included. Usually, the success of such devices has been judged subjectively, and no data are presented to substantiate the claims.

REFERENCES

1. "Steam-Electric Plant Factors." National Coal Association, Washington, DC. 1975.

2. R. M. Bailey et al. "A List of Common and Scientific Names of Fishes from the United States and Canada." American Fisheries Society, Special Publication No. 6, Third Edition. 1970.

ARGONNE NATIONAL LABORATORY

As part of a program to assess the environmental impacts of U.S. power plants, the Environmental Statement Project at Argonne National Laboratory is conducting a national survey on the impingement of fish at cooling water intakes, and we would appreciate your assistance.

Information on fish impingement is being collected on a routine basis by a number of companies, especially under provisions of the Technical Specifications requirement of the Nuclear Regulatory Commission and/or the Public Law 92-500, Section 316 (b), requirement of the Environmental Protection Agency. To date, however, there has been no attempt to disseminate, on a national basis, the data and experience gained from these individual collection efforts.

We intend to compile much of this information in a series of reports that we feel will aid in planning improvements in the design, siting, and operation of cooling water intakes and that will be of use to utility company biologists and engineers, to environmental investigators and consultants, and to regulatory agencies.

Enclosed is a list of the information we are requesting for each U.S. fossil-fuel station with a generating capacity of 500 MWe or greater and for each U.S. nuclear power plant. The list does look exhaustive, but we would appreciate receiving whatever information is available at this time. We intend to complete our study as soon as possible and would like to publish the reports in a timely fashion.

Please feel free to contact me for further information concerning the study or the data we are requesting. My phone number is (312) 739-7711, Ext. 2463.

Sincerely yours,

R. K. Sharma, Ph.D.
Fisheries Scientist - Ecologist
Environmental Statement Project

Enclosure

9700 South Cass Avenue, Argonne, Illinois 60439 · Telephone 312-739-7711 · TWX 910-258-3285 · WUX LB, Argonne, Illinois

Fig. 1. Explanatory Letter.

INFORMATION REQUESTED ON COOLING WATER INTAKES AND FISH IMPINGEMENT

1. Description of the intake site, including brief characteristics of the topography and the depth contours of the water body. (Please include any site parameters that you feel make it unique with respect to local fish populations.)

2. Description of the intake design from outermost bar racks to the circulating water pumps. Please provide dimensions where available and describe all structures in the intake forebays, skimmer wall, intake bays, number of bays, number and type of screens, and number of pumps. Also provide intake design drawings to show overall layout and details of the intake bays and screens.

3. Description of intake operational parameters, such as flow rate, intake velocity at outermost bar racks, summer and winter operation (if different), winter recirculation for de-icing, etc. Please include actual flow rate data for the dates of sampling, if available.

4. List of fish species present in the body of water, preferably by seasonal abundance.

5. Number of fish impinged, total and by species for each of the sampling dates, or by weekly or monthly summary tables.

6. Description of the fish impingement sampling program, frequency of sampling, subsampling procedures, etc.

7. Various intake design and operational modifications attempted by your company to reduce fish impingement and your comments regarding success of each modification in reducing fish impingement.

8. Any publications or reports prepared by your company that deal specifically with fish impingement problems.

Mail information to:

Dr. R. K. Sharma
Fisheries Scientist - Ecologist
Environmental Statement Project
Argonne National Laboratory
Argonne, Illinois 60439

Fig. 2. Information Request.

Fig. 3. Plant Locations, Inland Waters.

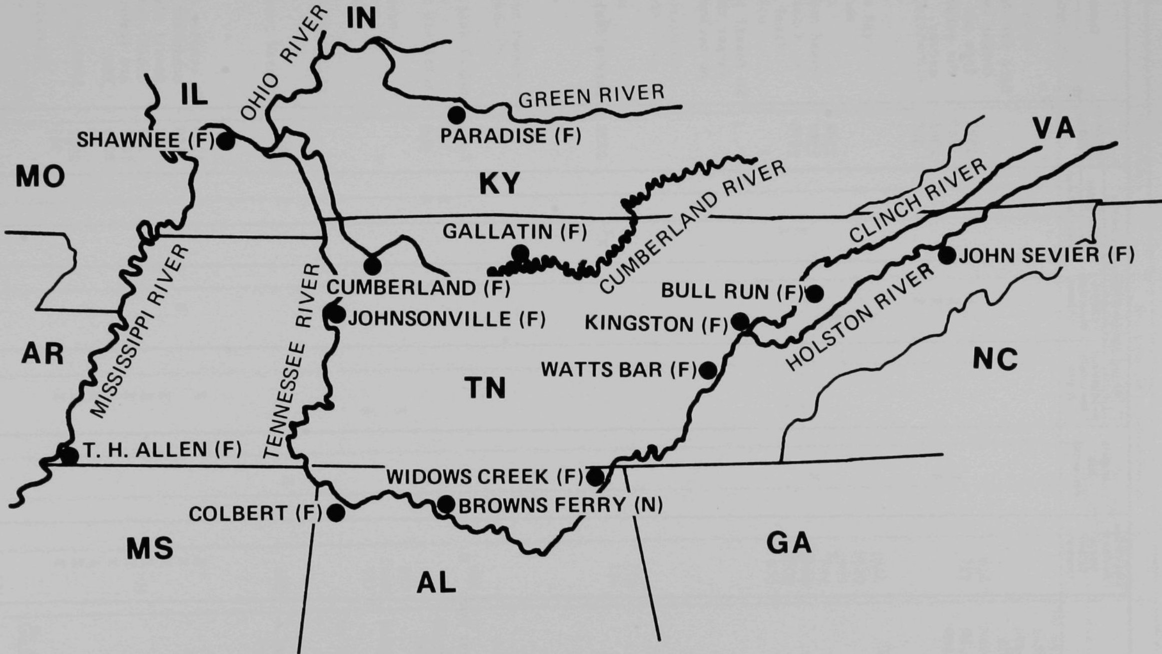


Fig. 4. Plant Loctions, TVA System.

Table I. The 316(b) Status (on 1 August 1976) of U. S. Power Plants (Fossil over 500 MWe, and Nuclear)

State / Utility / Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available: No Impingement Monitoring in Progress	No Impingement Information Available: 316(b) or Similar Study Underway	316(b) Status: Exempt	316(b) Status: Unknown	Capability (MWe)	Comments
ALABAMA								
Alabama Power Co.								Data for Gaston and Gorgas were in a form not usable for the purpose of the survey.
Barry				X			1525	
E. C. Gaston		X		X			1880	
Gorgas		X		X			1341	
Green County				X			500	
Tennessee Valley Authority								
Browns Ferry	X						2304	
Colbert		X					1397	
Widows Creek	X						1978	
ALASKA								No fossil plants larger than 500 MWe; no nuclear plants.
ARIZONA								
Arizona Public Service Co.								
Four Corners					X		2234	Uses a cooling lake.
ARKANSAS								
Arkansas Power & Light Co.								
Arkansas Nuclear One	X						836	
Lake Catherine						X	756	
Robert Ritchie						X	900	
CALIFORNIA								
Los Angeles Dept. of Water & Power								
Haynes		X					1606	
Pacific Gas & Electric Co.								
Contra Costa	X		X				1260	No studies are being conducted for the fossil plants until 316(b) guidelines are issued by the EPA.
Diablo Canyon	X			X			2120	
Humboldt Bay	X		X				172	
Hunters Point	X		X				377	
Morro Bay	X		X				1002	
Moss Landing	X		X				2060	
Oleum	X		X				87	
Pittsburg	X		X				2002	
Potrero	X		X				323	
Sacramento Municipal Utility District								
Rancho Seco		X			X		913	Canal makeup water.

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available				Capability (MWe)	Comments
			No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status: Exempt	316(b) Status: Unknown		
CALIFORNIA (cont'd)								
San Diego Gas & Electric Co.								No utility response; information obtained from Calif Regional Water Qual Contl Bd, San Diego Region.
Encina			X				614	
South Bay			X				729	
Southern California Edison Co.								
Alamitos Bay			X				1950	
El Segundo			X				1020	
Etiwanda			X				904	
Huntington Beach			X				870	
Ormond Beach		X		X			1500	
Redondo Beach		X		X			1602	
San Onofre	X						430	
COLORADO								
Public Service Co. of Colorado								
Cherokee		X					710	
Fort St. Vrain		X	X				330	
CONNECTICUT								
Connecticut Yankee Atomic Power Co.								
Connecticut Yankee	X						600	
Northeast Utilities								Inadequate response from utility.
Middletown				X			837	
Millstone	X						1482	Information from NRC.
Montville				X			577	
United Illuminating Co.								
Bridgeport Harbor				X			600	A 316(b) report to be completed in Dec 76.
DELAWARE								
Delmarva Power & Light Co.								
Edge Moor	X						791	
DISTRICT OF COLUMBIA								
Potomac Electric Power Co.								No utility response.
Benning						X	684	

Table I. Continued

State / Utility / Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available: No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status: Exempt	316(b) Status: Unknown	Capability (MWe)	Comments
FLORIDA								
Florida Power & Light Co.								No information on fossil plants was received.
Cape Canaveral			X				762	
Fort Myers			X				535	
Port Everglades			X				1214	
Riviera						X	692	
St. Lucie				X			1620	Only one St. Lucie unit (810 MWe) is fully operational.
Sanford			X				918	
Turkey Point	X				X		2321	
Florida Power Corp.								No utility response; permit for Anclote has been applied for - or study underway.
Anclote				X			556	
Crystal River	X						1782	
Gulf Power Co.								No utility response.
Crist				X			1045	316(b) demo approved.
Ellis			X				1000	316(b) propsl in prep.
Jacksonville Electric Authority								No utility response.
Northside			X				824	316(b) propsl in prep.
Orlando Utilities Comm.								No utility response.
Indian River			X				665	316(b) propsl in prep.
Tampa Electric Co.								No utility response.
Big Bend			X				891	316(b) propsl in prep.
F. J. Gannon						X	1062	
GEORGIA								
Georgia Power Co.								No utility response.
Bowen			X				2319	
Hammond			X				800	
Harllee Branch			X				1540	
Hatch		X					1581	Information from NRC.
J. McDonough						X	569	
Yates			X				1250	
HAWAII								No fossil plants larger than 500 MWe; no nuclear plants.
IDAHO								No fossil plants larger than 500 MWe; no nuclear plants.
ILLINOIS								
Central Illinois Light Co.								No utility response.
E. D. Edwards			X				725	

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available: No Impingement Monitoring in Progress	No Impingement Information Available: 316(b) or Similar Study Underway	No Impingement Information Available: 316(b) Status: Exempt	No Impingement Information Available: 316(b) Status: Unknown	Capability (MWe)	Comments
ILLINOIS (cont'd)								
Central Illinois Public Service								No utility response.
Coffeen			X				1005	NPDES permit issued.
Meredosia				X			354	A 316(b) proposal has been submitted.
Commonwealth Edison Co.								
Dresden				X			1865	
Fisk						X	547	
Joliet						X	1787	
Kincaid						X	1319	
Powerton			X				893	
Ridgeland						X	690	
Quad Cities	X						1600	
Waukegan	X						933	
Will County			X				1269	
Zion	X						2196	
Electric Energy, Inc.								
Joppa		X					1041	
Illinois Power Co.								
Baldwin	X						1258	
Wood River	X						657	
Union Electric Co.								Inadequate response from utility.
Cahokia			X				304	
Venice			X				500	Sep 76 retirement.
INDIANA								
Commonwealth Edison Co.								
State Line	X						968	
Indiana-Kentucky Electric Corp.								
Clifty Creek	X						1290	
Indiana & Michigan Electric Co.								
Tanners Creek			X				1040	316(b) propsl in prep.
Indianapolis Power & Light Co.								No utility response.
Petersburg			X				650	316(b) proposals may
E. W. Stout						X	787	be in preparation.

Table I. Continued

State / Utility / Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available: No Impingement Monitoring in Progress	No Impingement Information Available: 316(b) or Similar Study Underway	316(b) Status: Exempt	316(b) Status: Unknown	Capability (MWe)	Comments
INDIANA (cont'd)								
Northern Indiana Public Service Co.								Inadequate response from utility.
Bailly	X						616	
Michigan City	X						736	
D. H. Mitchell	X						529	
Public Service Co. of Indiana, Inc.								Inadequate response from utility.
Cayuga						X	1025	
R. A. Gallagher				X			637	
Wabash River.						X	881	
Southern Indiana Gas & Electric Co.								
Warrick			X				732	A 316(b) proposal may be in preparation.
IOWA								
Iowa Public Service Co.								
George Neal	X						496	
Iowa Electric Light & Power Co.								
Duane Arnold		X			X		529	
KANSAS								
Kansas City Power & Light Co.								Inadequate response from utility.
La Cygne						X	893	
Kansas Gas & Electric Co.								No utility response.
Gordon Evans						X	539	
Kansas Power & Light Co.								
Lawrence					X		613	Closed-cycle cooling.
KENTUCKY								
Big Rivers Electric Corp.								
Coleman			X				455	A 316(b) proposal may be in preparation.

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available: No Impingement Monitoring in Progress	No Impingement Information Available: 316(b) or Similar Study Underway	316(b) Status: Exempt	316(b) Status: Unknown	Capability (MWe)	Comments
KENTUCKY (cont'd)								
Kentucky Power Co.								No utility response.
Big Sandy						X	1003	
Kentucky Utilities Co.								Inadequate response from utility.
E. W. Brown						X	706	
Ghent	X						525	
Green River	X						242	
Louisville Gas & Electric Co.								No utility response.
Cane Run			X				992	316(b) proposals may be in preparation.
Mill Creek			X				660	
Tennessee Valley Authority								
Paradise (A)	X						1408	Paradise uses cooling towers.
Paradise (B)	X						1150	
Shawnee		X					1750	
LOUISIANA								
Gulf States Utilities Co.								Inadequate response from utility.
R. S. Nelson						X	982	
Willow Glen	X						1586	
Louisiana Power & Light Co.								
Little Gypsy		X		X			1251	
Ninemile Point		X		X			1917	
Sterlington		X					523	
New Orleans Public Service, Inc.								No utility response.
Michoud						X	959	
MAINE								
Maine Yankee Atomic Power Co.								
Maine Yankee	X						855	
MARYLAND								
Baltimore Gas & Electric Co.								No utility response.
Calvert Cliffs	X						1690	A 316(b) propsl may be in prep for Wagner.
H. A. Wagner			X				990	

Table I. Continued

State / Utility / Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available: No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status: Exempt	316(b) Status: Unknown	Capability (MWe)	Comments
MARYLAND (cont'd)								
Potomac Electric Power Co.								No utility response.
Chalk Point			X				708	NPDES permit appl may be in prep for Chalk Point.
Dickerson						X	570	
Morgantown						X	1364	
MASSACHUSETTS								
Boston Edison Co.								No utility response; information obtained from EPA Region I.
Mystic	X						1218	
New-Boston						X	718	
Pilgrim	X						655	
Canal Electric Co.								
Canal	X						1120	
New England Power Co.								
Brayton Point	X						1590	
Salem Harbor	X						775	
Yankee Atomic Electric Co.								
Yankee Atomic	X						185	
MICHIGAN								
Consumers Power Co.								
Big Rock	X						75	316(b) demo approved on 28 Jan 75.
J. H. Campbell	X						650	
B. C. Cobb	X						531	
D. E. Karn	X						530	Same as Big Rock.
Palisades	X						812	Same as Big Rock.
J. C. Weadock	X						615	Same as Big Rock.
Detroit Edison Co.								No utility response.
Conners Creek				X			460	316(b) demos approved on 29 Jul 75 for Conners Creek, River Rouge, St. Clair, & Trenton Channel.
Monroe		X		X			3011	
River Rouge				X			842	
St. Clair				X			1798	
Trenton Channel				X			700	
Indiana & Michigan Power Co.								
D. C. Cook	X						1100	

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available: No Impingement Monitoring in Progress	No Impingement Information Available: 316(b) or Similar Study Underway	316(b) Status: Exempt	316(b) Status: Unknown	Capability (MWe)	Comments
MINNESOTA								
Minnesota Power & Light Co.								
Clay Boswell		X		X			462	
Northern States Power Co.								Inadequate response from utility; info obtained from Minn Pollut Cntl Board.
A. S. King		X					560	
Monticello		X					538	
Prairie Island	X						1040	
MISSISSIPPI								
Mississippi Power Co.								Inadequate response from utility.
Jack Watson						X	1012	
Mississippi Power & Light Co.								Inadequate response from utility.
G. Andrus			X				750	
Baxter Wilson		X					1328	
MISSOURI								
Associated Electric Cooperative, Inc.								
New Madrid			X				600	316(b) propsl in prep.
Kansas City Power & Light Co.								Inadequate response from utility.
Hawthorne		X		X			925	
Montrose					X		546	
Missouri Public Service Co.								No utility response.
Sibley						X	519	
Union Electric Co.								Inadequate response from utility.
Labadie			X				2220	NPDES permit appl may be in prep for Labadie.
Meramec						X	800	
Sioux						X	978	
MONTANA								No fossil plants larger than 500 MWe; no nuclear plants.
NEBRASKA								
Nebraska Public Power District								Information obtained from EPA Region VI.
Cooper	X						764	
Gerald Gentleman				X			650	

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available				Capability (MWe)	Comments
			No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status			
					Exempt	Unknown		
NEBRASKA (cont'd)								
Omaha Public Power District								No utility response.
Fort Calhoun				X			481	
Nebraska City				X			575	
North Omaha				X			600	
NEVADA								
Southern California Edison Co.								Inadequate response from utility.
Mohave						X	1580	
NEW HAMPSHIRE								No fossil plants larger than 500 MWe; no nuclear plants.
NEW JERSEY								
Jersey Central Power & Light Co.								
Oyster Creek	X						670	
Public Service Electric & Gas Co.								No utility response.
Bergen			X				650	
Burlington			X		X		455	Partly closed-cycle.
Essex			X				700	
Hudson			X				1115	NPDES permit appls in prep for the utility's plants except Burlington.
Kearny			X				841	
Linden			X				613	
Mercer			X				653	
Seawaren			X				850	
NEW MEXICO								No fossil plants larger than 500 MWe; no nuclear plants.
NEW YORK								
Central Hudson Gas & Electric Corp.								Inadequate response from utility.
Danskammer Point			X				472	
Roseton					X		1140	Closed-cycle cooling.
Consolidated Edison Co. of New York, Inc.								Inadequate response from utility on all but Astoria & Indian Point.
Astoria	X						1625	
East River			X				454	
Hudson Ave.						X	700	316(b) proposals may be in prep for East River & Arthur Kill.
Indian Point	X						1158	
Arthur Kill			X				826	
Ravenswood						X	1726	
Waterside						X	593	

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available				Capability (MWe)	Comments
			No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status: Exempt	316(b) Status: Unknown		
NEW YORK (cont'd)								
Long Island Lighting Co.								
Northport	X						1158	
Niagara Mohawk Power Corp.								No utility response.
Dunkirk				X			640	
C. R. Huntley				X			830	
Nine Mile Point	X						642	
Orange & Rockland Utilities, Inc.								No utility response.
Bowline Point			X				1242	
Lovett					X		504	Closed-cycle cooling.
Rochester Gas & Electric Corp.								
Ginna	X						490	
NORTH CAROLINA								
Carolina Power & Light Co.								
Brunswick	X						1642	
Roxboro			X				1705	316(b) propsl in prep.
L. V. Sutton			X				554	316(b) propsl in prep.
Duke Power Co.								No utility response.
Allen	X						1140	
Belews Creek				X			1060	EPA is reviewing applications from the four plants that indicate "study underway."
Buck		X		X			364	
Cliffside				X			770	
Marshall					X		2025	
Riverbend		X		X			631	
NORTH DAKOTA								No fossil plants larger than 500 MWe; no nuclear plants.
OHIO								
Cincinnati Gas & Electric Co.								No utility response.
W. C. Beckjord				X			1168	
Cleveland Electric Illuminating Co.								No utility response.
Ashtabula			X				640	NPDES permit appls may be in prep for the four plants.
Avon Lake			X				1275	
Eastlake			X				1045	
Lake Shore			X				518	

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available: No Impingement Monitoring in Progress	No Impingement Information Available: 316(b) or Similar Study Underway	316(b) Status: Exempt	316(b) Status: Unknown	Capability (MWe)	Comments
OHIO (cont'd)								
Columbus & Southern Ohio Electric Co.								
Conesville			X				1275	Appl may be in prep.
Ohio Edison Co.								
R. E. Burger		X					544	
Gavin			X				1300	Propsl may be in prep.
W. H. Sammis		X					1980	
Ohio Power Co.								No utility response.
Cardinal			X				1180	NPDES permit appls
Muskingum River			X				1467	may be in prep for
Philo			X				500	the three plants.
Ohio Valley Electric Corp.								No utility response.
Kyger Creek			X				1075	NPDES appl in prep.
Toledo Edison Co.								No utility response.
Bay Shore			X				639	
OKLAHOMA								
Oklahoma Gas & Electric Co.								No utility response.
Horseshoe Lake						X	949	
Mustang						X	505	
Seminole						X	1100	
Public Service Co. of Oklahoma								No utility response.
Northeastern						X	643	
OREGON								
Portland General Electric Co.								
Trojan	X						659	Closed-cycle cooling.
PENNSYLVANIA								
Allegheny Power Service Corp.								Inadequate response from utility.
Hatfield's Ferry					X		1728	

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available: No Impingement Monitoring in Progress	No Impingement Information Available: 316(b) or Similar Study Underway	No Impingement Information Available: 316(b) Status: Exempt	No Impingement Information Available: 316(b) Status: Unknown	Capability (MWe)	Comments
PENNSYLVANIA (cont'd)								
Duquesne Light Co.								No utility response.
Cheswick						X	525	
Elrama						X	425	
Shippingport						X	100	
Metropolitan Edison Co.								
Three Mile Island	X						871	
Pennsylvania Electric Co.								No utility response.
Homer City						X	1320	
Shawville			X				640	Appl may be in prep.
Pennsylvania Power & Light Co.								No utility response.
Brunner Island						X	1559	
Conemaugh						X	1872	
Keystone						X	1872	
Montour						X	1642	
Philadelphia Electric Co.								Inadequate response from utility.
Eddystone			X				1090	
Peach Bottom	X						2130	
RHODE ISLAND								No fossil plants larger than 500 MWe; no nuclear plants.
SOUTH CAROLINA								
Carolina Power & Light Co.								
H. B. Robinson	X						839	
Duke Power Co.								Inadequate response from utility.
Oconee				X			2613	
South Carolina Electric & Gas Co.								
Canadys						X	490	
Wateree	X						772	Hot-wea cooling twrs.
A. M. Williams	X						633	Hot-wea cooling twrs.
SOUTH DAKOTA								No fossil plants larger than 500 MWe; no nuclear plants.

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available				Capability (MWe)	Comments
			No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status			
					Exempt	Unknown		
TENNESSEE								
Tennessee Valley Authority								
T. H. Allen	X						990	
Bull Run		X					950	
Cumberland	X						2600	
Gallatin	X						1255	
Johnsonville		X					1485	
Kingston	X						1700	
John Sevier	X						847	
Watts Bar	X						240	
TEXAS								
Austin Electric Dept.								Utility not contacted.
Holly St.						X	555	
Central Power & Light Co.								No utility response.
Barney M. Davis	X						650	
L. C. Hill						X	545	
Nueces Bay						X	569	
Victoria						X	520	
Dallas Power & Light Co.								Inadequate response from utility.
Big Brown			X				1187	
Lake Hubbard			X				890	
Monticello			X				593	
Mountain Creek			X				928	
North Lake			X				700	
Gulf States Utilities Co.								
Lewis Creek		X		X			543	316(b) demo underway.
Sabine		X		X			1544	316(b) demo underway.
Houston Lighting & Power Co.								
Sam Bertron						X	751	
Cedar Bayou	X						2250	
Greens Bayou						X	741	
W. A. Parish						X	1119	
P. H. Robinson		X		X			2178	
Webster						X	550	
T. H. Wharton						X	562	
Lower Colorado River Authority								Utility not contacted.
Sam Gideon						X	565	

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available: No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status: Exempt	316(b) Status: Unknown	Capability (MWe)	Comments
TEXAS (cont'd)								
San Antonio Public Service Board								Utility not contacted.
Victor H. Braunig						X	885	
Sommers						X	872	
Southwestern Electric Power Co.								
Knox Lee		X	X				513	
Wilkes		X	X				879	
Texas Electric Service Co.								Inadequate response from utility.
Eagle Mountain		X					706	Impingement info was in a form not usable for the purpose of the survey.
Graham						X	635	
Handley		X					523	
Morgan Creek						X	848	
Permian Basin						X	702	
Texas Power & Light Co.								Inadequate response from utility.
Stryker Creek						X	675	
Tradinghouse Creek						X	1340	
Valley						X	1100	
UTAH								No fossil plants larger than 500 MWe; no nuclear plants.
VERMONT								
Vermont Yankee Nuclear Power Corp.								No utility response; some information obtained from NRC.
Vermont Yankee		X					563	
VIRGINIA								
Appalachian Power Co.								No utility response.
Clinch River						X	669	
Potomac Electric Power Co.								
Potomac River			X				486	
Virginia Electric & Power Co.								Inadequate response from utility.
Chesterfield			X				1481	
Portsmouth			X				650	
Possum Point			X				491	
Surry	X						1576	
Yorktown			X				1257	

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available: No Impingement Monitoring in Progress	No Impingement Information Available: 316(b) or Similar Study Underway	No Impingement Information Available: 316(b) Status: Exempt	No Impingement Information Available: 316(b) Status: Unknown	Capability (MWe)	Comments
WASHINGTON								
Pacific Power & Light Co.								No utility response.
Centralia						X	1330	
Washington Public Power Supply System								
Hanford	X						700	MWe quoted by a WPPSS representative.
WEST VIRGINIA								
Allegheny Power Service Corp.								Inadequate response from utility.
Fort Martin					X		1152	Both plants may have off-stream cooling.
Harrison					X		1368	
Appalachian Power Co.								No utility response.
J. E. Amos						X	2775	
Philip Sporn			X				1060	Propsl may be in prep.
Ohio Power Co.								No utility response.
Kammer						X	675	
Mitchell						X	1498	
Virginia Electric & Power Co.								Inadequate response from utility.
Mount Storm						X	1662	
WISCONSIN								
Dairyland Power Cooperative								
Genoa				X			360	
La Crosse	X						48	
Wisconsin Electric Power Co.								
Lakeside	X						310	
Oak Creek	X						1690	
Port Washington	X						400	
Wisconsin Michigan Power Co.								
Point Beach	X						1026	
Wisconsin Power & Light Co.								
Columbia					X		527	Uses a cooling lake.

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available				Capability (MWe)	Comments
			No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status			
					Exempt	Unknown		
WISCONSIN (cont'd)								
Wisconsin Public Service Corp.								
Kewaunee	X						535	
Pulliam	X						393	
WYOMING								
Pacific Power & Light Co.								Inadequate response from utility.
Jim Bridger		X					2000	
Dave Johnston		X					750	

Data were compiled from: "Steam-Electric Plant Factors," National Coal Association, Washington, DC, 1975 Edition; "Inforum," Cumulative Index for September 1975-February 1976, Atomic Industrial Forum, Inc., Washington, DC, 1976; "Electrical World Directory of Electric Utilities," McGraw-Hill, Inc., 1975-1976, 84th Edition, 1975; individual utility responses; and other sources as given in the comments column.

SUMMARY OF 316(b) STATUS OF U.S. POWER PLANTS

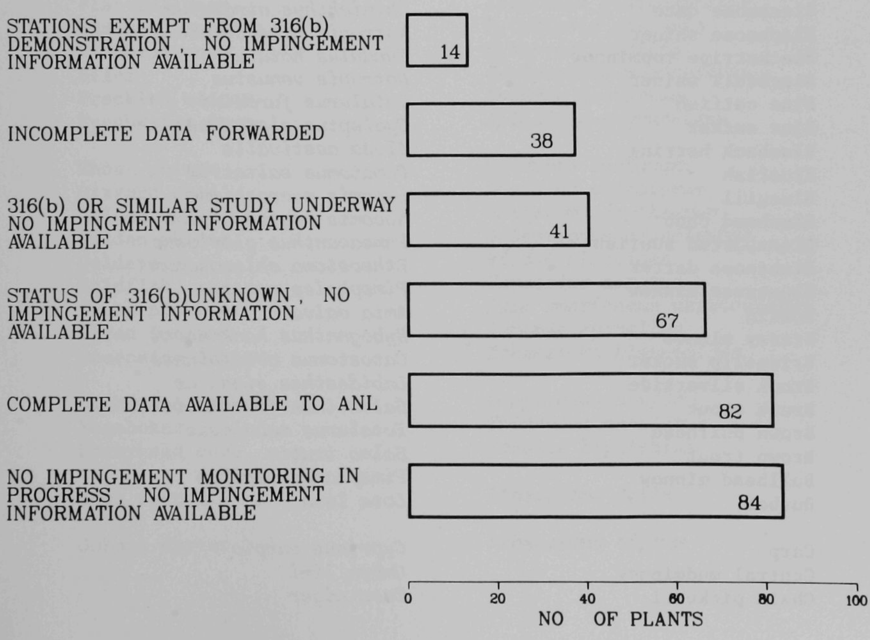


Table II. Index of Common Names Used in this Volume and the Corresponding Scientific Names

Common Name	Scientific Name
Alewife	*Alosa pseudoharengus*
Alligator gar	*Lepisosteus spatula*
American eel	*Anguilla rostrata*
American shad	*Alosa sapidissima*
Atlantic menhaden	*Brevoortia tyrannus*
Atlantic silverside	*Menidia menidia*
Atlantic tomcod	*Microgadus tomcod*
Banded killifish	*Fundulus diaphanus*
Banded pigmy sunfish	*Elassoma zonatum*
Banded sculpin	*Cottus carolinae*
Bay anchovy	*Anchoa mitchilli*
Bigeye chub	*Hybopsis amblops*
Bigmouth buffalo	*Ictiobus cyprinellus*
Bigmouth shiner	*Notropis dorsalis*
Black buffalo	*Ictiobus niger*
Black bullhead	*Ictalurus melas*
Black crappie	*Pomoxis nigromaculatus*
Black redhorse	*Moxostoma duquesnei*
Blackbanded sunfish	*Enneacanthus chaetodon*
Blackchin shiner	*Notropis heterodon*
Blacknose dace	*Rhinichthys atratulus*
Blacknose shiner	*Notropis heterolepis*
Blackstripe topminnow	*Fundulus notatus*
Blacktail shiner	*Notropis venustus*
Blue catfish	*Ictalurus furcatus*
Blue sucker	*Cycleptus elongatus*
Blueback herring	*Alosa aestivalis*
Bluefish	*Pomatomus saltatrix*
Bluegill	*Lepomis macrochirus*
Bluehead chub	*Nocomis leptocephalus*
Bluespotted sunfish	*Enneacanthus gloriosus*
Bluntnose darter	*Etheostoma chlorosomum*
Bluntnose minnow	*Pimephales notatus*
Bowfin	*Amia calva*
Brassy minnow	*Hybognathus hankinsoni*
Bridgelip sucker	*Catostomus columbianus*
Brook silverside	*Labidesthes sicculus*
Brook trout	*Salvelinus fontinalis*
Brown bullhead	*Ictalurus nebulosus*
Brown trout	*Salmo trutta*
Bullhead minnow	*Pimephales vigilax*
Burbot	*Lota lota*
Carp	*Cyprinus carpio*
Central mudminnow	*Umbra limi*
Chain pickerel	*Esox niger*

Table II. Continued

Common Name	Scientific Name
Channel catfish	*Ictalurus punctatus*
Chestnut lamprey	*Ichthyomyzon castaneus*
Chinook salmon	*Oncorhynchus tshawytscha*
Chiselmouth	*Acrocheilus alutaceus*
Coho salmon	*Oncorhynchus kisutch*
Comely shiner	*Notropis amoenus*
Common shiner	*Notropis cornutus*
Creek chub	*Semotilus atromaculatus*
Creek chubsucker	*Erimyzon oblongus*
Cutlips minnow	*Exoglossum maxillingua*
Cutthroat trout	*Salmo clarki*
Dollar sunfish	*Lepomis marginatus*
Dolly Varden	*Salvelinus malma*
Dusky shiner	*Notropis cummingsae*
Eastern mudminnow	*Umbra pygmaea*
Emerald shiner	*Notropis atherinoides*
Fallfish	*Semotilus corporalis*
Fantail darter	*Etheostoma flabellare*
Fathead minnow	*Pimephales promelas*
Flat bullhead	*Ictalurus platycephalus*
Flathead catfish	*Pylodictis olivaris*
Flathead chub	*Hybopsis gracilis*
Flier	*Centrarchus macropterus*
Freckled madtom	*Noturus nocturnus*
Freshwater drum	*Aplodinotus grunniens*
Ghost shiner	*Notropis buchanani*
Gizzard shad	*Dorosoma cepedianum*
Golden redhorse	*Moxostoma erythrurum*
Golden shiner	*Notemigonus crysoleucas*
Goldeye	*Hiodon alosoides*
Goldfish	*Carassius auratus*
Grass pickerel	*Esox americanus vermiculatus*
Green sunfish	*Lepomis cyanellus*
Greenside darter	*Etheostoma blennioides*
Highfin carpsucker	*Carpiodes velifer*
Hogchoker	*Trinectes maculatus*
Hornyhead chub	*Nocomis biguttatus*
Iowa darter	*Etheostoma exile*
Johnny darter	*Etheostoma nigrum*

Table II. Continued

Common Name	Scientific Name
Lake chubsucker	*Erimyzon sucetta*
Lake sturgeon	*Acipenser fulvescens*
Lake trout	*Salvelinus namaycush*
Largemouth bass	*Micropterus salmoides*
Largescale sucker	*Catostomus macrocheilus*
Lined topminnow	*Fundulus lineolatus*
Logperch	*Percina caprodes*
Longear sunfish	*Lepomis megalotis*
Longhead darter	*Percina macrocephala*
Longnose dace	*Rhinichthys cataractae*
Longnose gar	*Lepisosteus osseus*
Longnose sucker	*Catostomus catostomus*
Margined madtom	*Noturus insignis*
Mimic shiner	*Notropis volucellus*
Mississippi silverside	*Menidia audens*
Mooneye	*Hiodon tergisus*
Mosquitofish	*Gambusia affinis*
Mountain sucker	*Catostomus platyrhynchus*
Mountain whitefish	*Prosopium williamsoni*
Mud darter	*Etheostoma asprigene*
Mud sunfish	*Acantharchus pomotis*
Mummichog	*Fundulus heteroclitus*
Muskellunge	*Esox masquinongy*
Ninespine stickleback	*Pungitius pungitius*
Northern hog sucker	*Hypentelium nigricans*
Northern pike	*Esox lucius*
Northern squawfish	*Ptychocheilus oregonensis*
Northern studfish	*Fundulus catenatus*
Ohio lamprey	*Ichthyomyzon bdellium*
Orangefin madtom	*Noturus gilberti*
Orangespotted sunfish	*Lepomis humilis*
Orangethroat darter	*Etheostoma spectabile*
Pacific lamprey	*Entosphenus tridentatus*
Paddlefish	*Polyodon spathula*
Pallid sturgeon	*Scaphirhynchus albus*
Peamouth	*Mylocheilus caurinus*
Piedmont darter	*Percina crassa*
Pirate perch	*Aphredoderus sayanus*
Plains killifish	*Fundulus kansae*
Plains minnow	*Hybognathus placitus*
Pugnose minnow	*Notropis emiliae*
Pumpkinseed	*Lepomis gibbosus*
Quillback	*Carpiodes cyprinus*

Table II. Continued

Common Name	Scientific Name
Rainbow darter	*Etheostoma caeruleum*
Rainbow smelt	*Osmerus mordax*
Rainbow trout	*Salmo gairdneri*
Red shiner	*Notropis lutrensis*
Redbreast sunfish	*Lepomis auritus*
Redear sunfish	*Lepomis microlophus*
Redfin pickerel	*Esox americanus americanus*
Redfin shiner	*Notropis umbratilis*
Redline darter	*Etheostoma rufilineatum*
Redside shiner	*Richardsonius balteatus*
River carpsucker	*Carpiodes carpio*
River chub	*Nocomis micropogon*
River darter	*Percina shumardi*
River redhorse	*Moxostoma carinatum*
River shiner	*Notropis blennius*
Rock bass	*Ambloplites rupestris*
Rosyface shiner	*Notropis rubellus*
Rosyside dace	*Clinostomus funduloides*
Sand shiner	*Notropis stramineus*
Satinfin shiner	*Notropis analostanus*
Sauger	*Stizostedion canadense*
Sawcheek darter	*Etheostoma serriferum*
Sea lamprey	*Petromyzon marinus*
Shield darter	*Percina peltata*
Shorthead redhorse	*Moxostoma macrolepidotum*
Shortnose gar	*Lepisosteus platostomus*
Shovelnose sturgeon	*Scaphirhynchus platorynchus*
Sicklefin chub	*Hybopsis meeki*
Silver chub	*Hybopsis storeriana*
Silver lamprey	*Ichthyomyzon unicuspis*
Silver redhorse	*Moxostoma anisurum*
Silverband shiner	*Notropis shumardi*
Silverjaw minnow	*Ericymba buccata*
Silvery minnow	*Hybognathus nuchalis*
Skipjack herring	*Alosa chrysochloris*
Slenderhead darter	*Percina phoxocephala*
Slimy sculpin	*Cottus cognatus*
Slough darter	*Etheostoma gracile*
Smallfin redhorse	*Moxostoma robustum*
Smallmouth bass	*Micropterus dolomieui*
Smallmouth buffalo	*Ictiobus bubalus*
Sockeye salmon	*Oncorhynchus nerka*
Southern redbelly dace	*Phoxinus erythrogaster*
Speckled chub	*Hybopsis aestivalis*
Speckled dace	*Rhinichthys osculus*
Spotfin shiner	*Notropis spilopterus*
Spottail shiner	*Notropis hudsonius*

Table II. Continued

Common Name	Scientific Name
Spotted bass	*Micropterus punctulatus*
Spotted gar	*Lepisosteus oculatus*
Spotted sucker	*Minytrema melanops*
Starhead topminnow	*Fundulus notti*
Steelcolor shiner	*Notropis whipplei*
Steelhead	*Salmo gairdneri*
Stonecat	*Noturus flavus*
Stoneroller	*Campostoma anomalum*
Striped bass	*Morone saxatilis*
Striped killifish	*Fundulus majalis*
Striped shiner	*Notropis chrysocephalus*
Sturgeon chub	*Hybopsis gelida*
Suckermouth minnow	*Phenacobius mirabilis*
Suckermouth redhorse	*Moxostoma pappillosum*
Swallowtail shiner	*Notropis procne*
Swamp darter	*Etheostoma fusiforme*
Swampfish	*Chologaster cornuta*
Tadpole madtom	*Noturus gyrinus*
Tennessee snubnose darter	*Etheostoma simoterum*
Tessellated darter	*Etheostoma olmstedi*
Threadfin shad	*Dorosoma petenense*
Threespine stickleback	*Gasterosteus aculeatus*
Trout-perch	*Percopsis omiscomaycus*
Walleye	*Stizostedion vitreum vitreum*
Warmouth	*Lepomis gulosus*
Western sand darter	*Ammocrypta clara*
White bass	*Morone chrysops*
White catfish	*Ictalurus catus*
White crappie	*Pomoxis annularis*
White perch	*Morone americana*
White sturgeon	*Acipenser transmontanus*
White sucker	*Catostomus commersoni*
Whitetail shiner	*Notropis galacturus*
Yellow bass	*Morone mississippiensis*
Yellow bullhead	*Ictalurus natalis*
Yellow perch	*Perca flavescens*

YANKEE ATOMIC POWER PLANT (N)

SITE CHARACTERISTICS

The Yankee Atomic Power Plant (Yankee-Rowe) is located on the east bank of Sherman Pond, an impoundment of the Deerfield River in Rowe, Massachusetts.[1] The pond is about 1000 feet wide by 2.7 miles long and is 83 feet deep at full-pool conditions. The Massachusetts-Vermont state line transects Sherman Pond and there is no reciprocal fishing agreement between these states. Consequently, there is no management of the fisheries of Sherman Pond and no detailed studies of the pond's ecology are available. Table I is a list of fishes present in the pond.[1]

Extensive development of hydroelectric power-generation facilities has occurred on the Deerfield River. This is due to the large fall of the river, high annual precipitation on its watershed, and the availability of desirable sites for reservoirs and hydroelectric generating stations.

PLANT DESCRIPTION

The Yankee Atomic Power Plant utilizes a single-unit pressurized water reactor with a rated net capacity of 176 MWe. Condenser cooling is achieved by once-through cooling with water drawn from Sherman Pond.

INTAKE DESIGN AND OPERATION

Condenser circulating water is drawn from 80 feet below the surface of Sherman Pond through a 120-inch-diameter corrugated-steel pipe leading to the pumphouse-intake structure, a distance of about 300 feet. The intake structure contains traveling screens with 3/8-inch mesh, a service-water suction pipe, screen-wash apparatus, appropriate hydraulic equipment, and two circulating-water pumps. The two pumps deliver 139,138 gpm of fresh water at a 28-foot pumping head. Intake velocity at the point where water enters the intake pipe is about four fps.

IMPINGEMENT SAMPLING

Throughout most of 1975, 24-hour samples were taken at weekly intervals.

DATA AVAILABILITY

Fish impingement data for the Yankee Atomic Power Plant are available for all of 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 and H2 are histograms representing the three most abundant species as well as all species impinged at the Yankee Atomic Power Plant. These totals are summarized in Table II.

The plant was not in operation from 17 October until 18 December 1975, thus there was no impingement sampling during this period. The extrapolated totals are for the remaining 16 and 13 days of October and December, respectively.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCE

1. Wallace Davis, III, and R. B. MacPherson. "Biological and Thermal Conditions of the Deerfield River." Yankee Atomic Electric Company. January 1974.

Table I. Fishes of Sherman Pond

American eel	Yellow perch
White sucker	Rainbow trout
Rock bass	Brown trout
Pumpkinseed	Brook trout
Smallmouth bass	Lake trout
Golden shiner	
Fallfish	
Chain pickerel	
Brown bullhead	
Rainbow smelt	

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Rock Bass	Yellow Perch	Rainbow Smelt	Total
1975	11	13	473	587	1,144

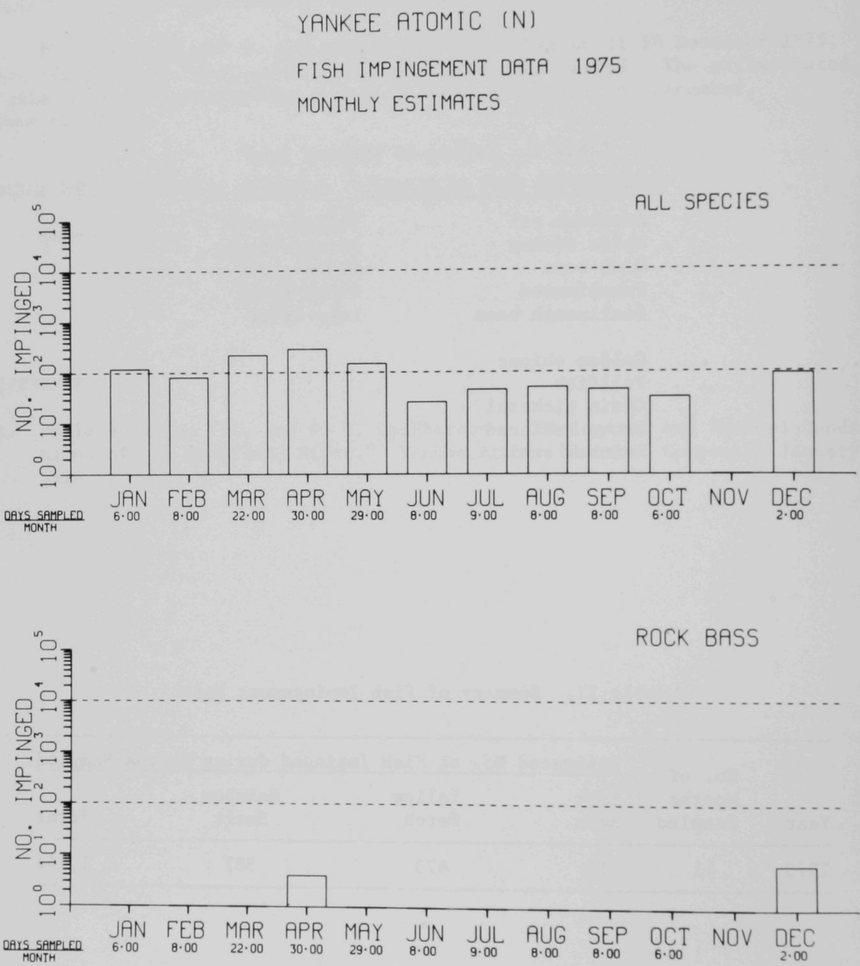


Fig. H1. Impingement Estimates.

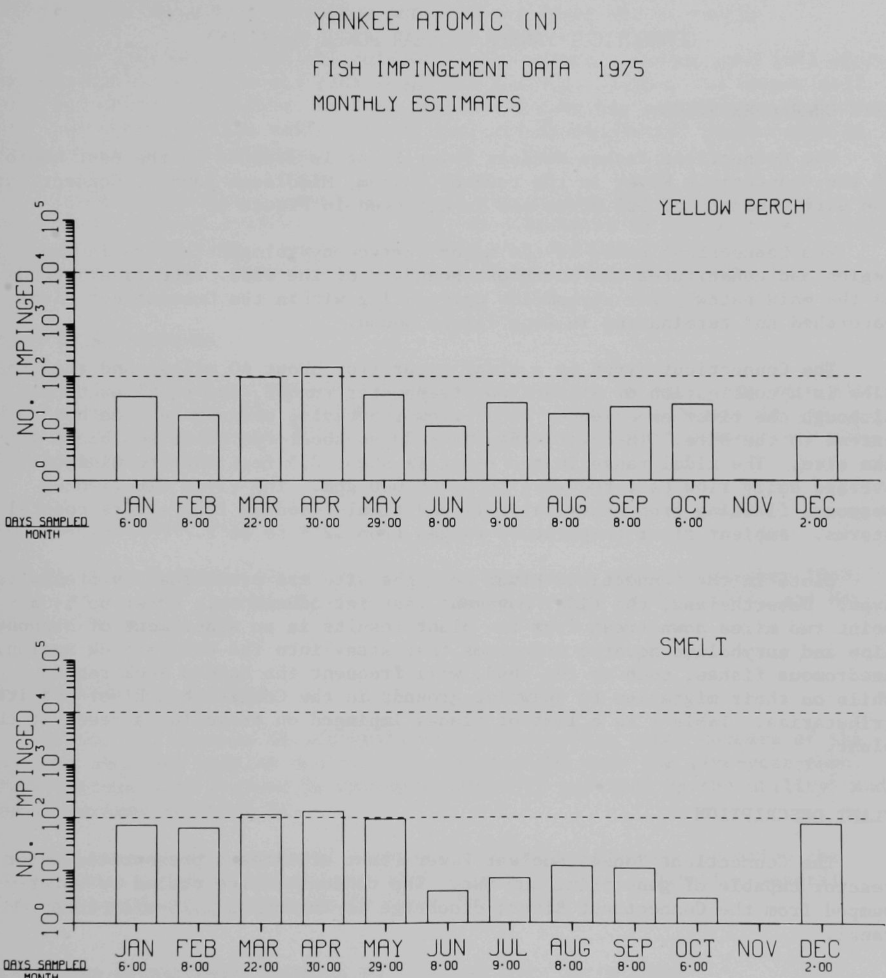


Fig. H2. Impingement Estimates.

CONNECTICUT YANKEE NUCLEAR POWER PLANT (N)

SITE CHARACTERISTICS

The Connecticut Yankee Nuclear Power Plant is located on the east shore of the Connecticut River in the town of Haddam, Middlesex County, Connecticut.[1] The site consists of 525 acres and is depicted in Figure 1.

The Connecticut River is the major surface hydrologic feature in the region and constitutes the southwest boundary of the site. The river serves as the main pathway for streamflow originating within the Connecticut River watershed and terminating in Long Island Sound.

The Connecticut River is a tidal river (for about 40 miles) and thus the flow is a combination of streamflow, freshwater runoff, and tidal exchange. Although the river experiences tidal-flow reversals, ocean waters do not extend to the site. The salt wedge extends to about two miles southeast of the site. The tidal range in the river is about 2.5 feet and the minimum average daily flow past the site is 6,700,000 gpm. The river experiences seasonal flooding from heavy rainfall and tidal flooding from severe coastal storms. Ambient river temperature ranges from 32°F to 86°F.

Biota in the Connecticut River near the site are predominantly freshwater type. Nevertheless, the tidal movement that introduces salt water up to a point two miles downstream from the plant results in an assortment of stenohaline and euryhaline aquatic organisms that stray into the Haddam Neck region. Anadromous fishes, such as the shad, will frequent the Haddam Neck region while on their migration to spawning grounds in the Connecticut River and its tributaries. Table I is a list of fishes impinged on traveling screens at the plant.

PLANT DESCRIPTION

The Connecticut Yankee Nuclear Power Plant utilizes a pressurized water reactor capable of generating 600 MWe. The condensers are cooled by water pumped from the Connecticut River; discharge is through a 1.16-mile-long canal.

INTAKE DESIGN AND OPERATION

Water required for turbine-exhaust steam condensers and plant-service use enters the plant through an inlet structure constructed on the bank of the Connecticut River; a diagram of the structure is shown in Figure 2. Design features include four separate intake bays, each containing a trash rack and a traveling screen. Each bay is about 12 feet wide at the trash rack and narrows to 11 feet at the screens. Each of the screens is ten feet wide, 41 feet center to center of the sprockets, and has 3/8-inch-square openings. Piping for recirculation of hot water from the condenser discharge to the inlet structure is provided to keep the latter ice-free. The screens are designed for continuous operation and flushing under manual control.

After passing through the screens, water enters a common pump well where the service-water pumps and fire pumps are located. Beyond the common well there are short partitions, in line with the intake-bay partitions, that form four individual suction wells for the four circulating-water pumps, each of which is rated at 93,000 gpm.

Intake velocities across the area of the opening of the downstream intake bay, assumed typical of the four, were measured by the USGS at a tidal stage of plus two feet. Velocities ranged from 0.95 to 1.76 fps, with an average of 1.2 fps. Velocity through the screen openings is about two fps.

IMPINGEMENT SAMPLING

Counts of fish impinged on the traveling screens at the plant were made noncontinuously from 1968 through 1972. Because of inconsistency in the daily counting breakdown, data were reduced to daily counts summed over all bays or time periods.

DATA AVAILABILITY

Periods of available impingement data are April through December 1968, all of 1969, July through October 1970, March through October 1971, and May through December 1972.[2]

IMPINGEMENT DATA SUMMARY

Figures H1 through H6 are histograms representing total numbers of the two most abundant species and all species impinged over the five-year span. These numbers were derived by extrapolating data provided by the utility[2] and are summarized in Table II.

For various environmental reasons the third, and on one occasion the second, most abundant species varied from year to year. Data for several abundant species are presented in Table III.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

Connecticut Yankee has utilized an electrically energized fish barrier intermittently in 1970 and regularly since 1971.[3] In brief, the barrier consists of a series of vertical aluminum tubes that can be pulsed with high voltage on a programmed schedule. This electrified grid (Fig. 3) has been shown to be quite effective in preventing fish from entering the inlet structure. Further experimentation has supported the original results of impingement reductions of more than 75%. A detailed description and discussion of the barrier has been prepared.[4]

REFERENCES

1. "Final Environmental Statement, Haddam Neck (Connecticut Yankee) Nuclear Power Plant." USAEC Directorate of Licensing. Docket No. 50-213. October 1973.

2. "Summary of the Environmental Assessment of the Once-Through Condenser Cooling System." Northeast Utilities Co. September 1974.

3. Personal communications with Bonde Johnson, Northeast Utilities Company.

4. S. B. Saila and W. H. Mowbray. "Evaluation of an Electric Fish Barrier at a Power Plant Intake." University of Rhode Island, Kingston, Rhode Island. 1972.

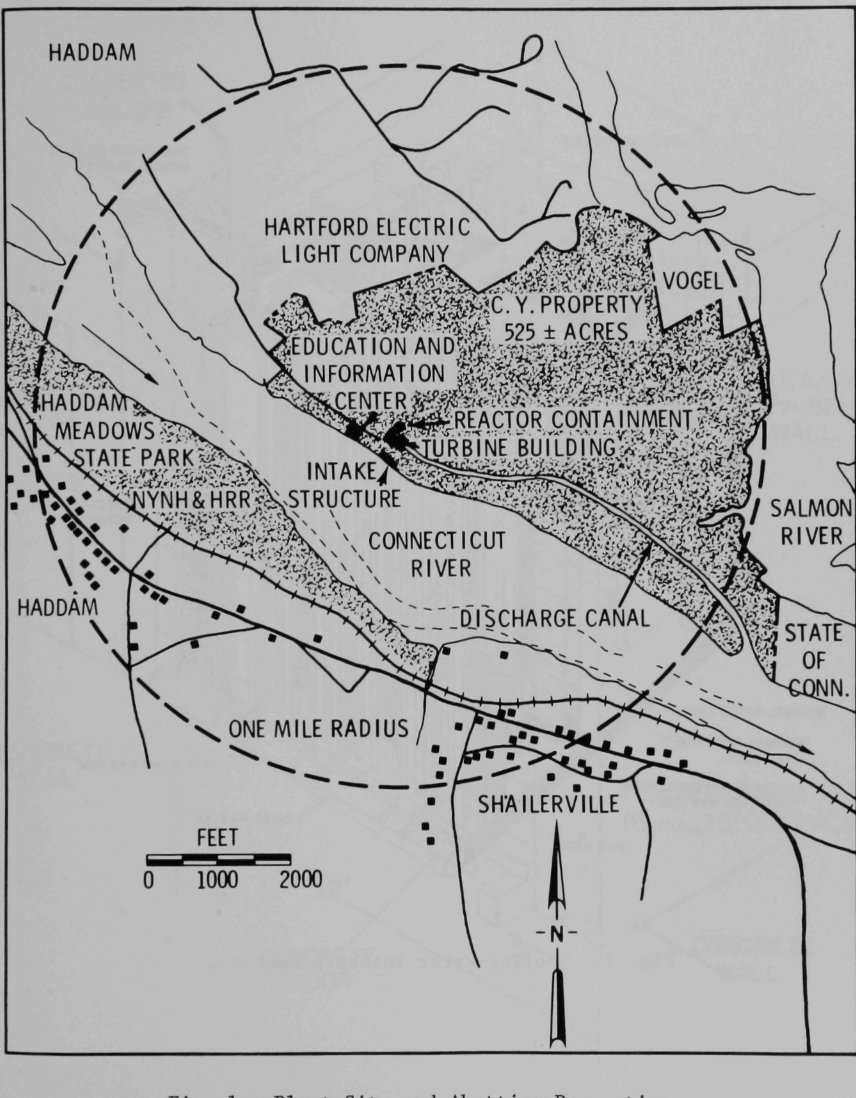


Fig. 1. Plant Site and Abutting Properties.

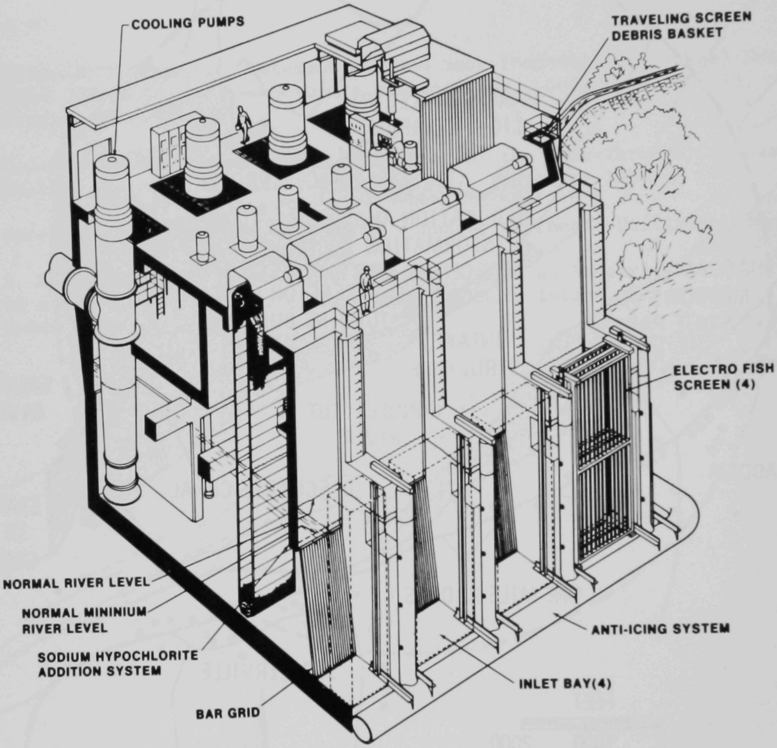


Fig. 2. Cooling-Water Intake Structure.

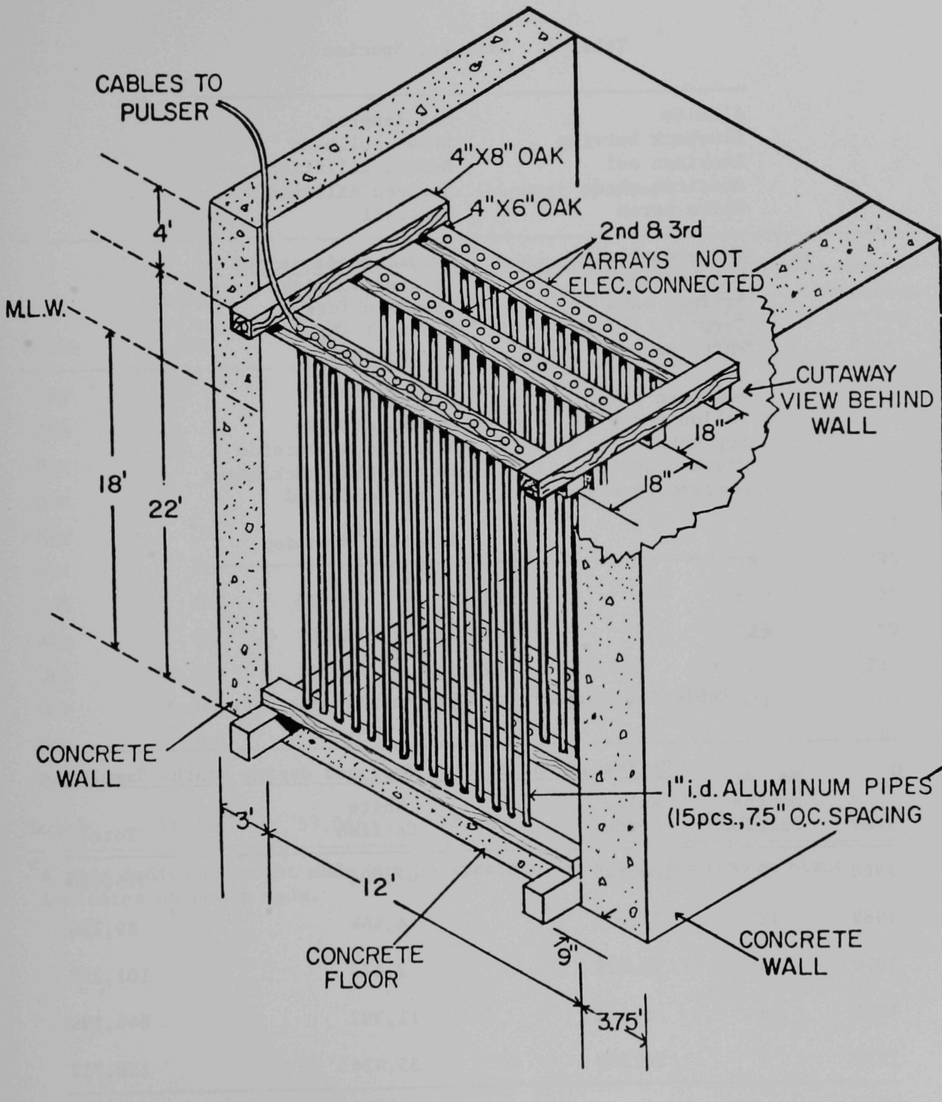


Fig. 3. Electric Fish Barrier.

Table I. Impinged Species

Alewife	Sea lamprey
Blueback herring	Brown bullhead
American eel	Banded killifish
American shad	Striped killifish
White perch	Bluegill
White catfish	Pumpkinseed
Rainbow smelt	Longear sunfish
Striped bass	Common shiner
Carp	Spottail shiner
White sucker	Bay anchovy
Northern pike	Bluefish
Yellow perch	Golden shiner
Hogchoker	Atlantic silverside
Black crappie	Threespine stickleback
Largemouth bass	Atlantic tomcod
	Atlantic menhaden

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled		
		White Perch	White Catfish	Total
1968	9	120,145	67,008	325,588
1969	12	27,079	4,464	89,786
1970	4	58,639	2,473	101,258
1971	8	9,161	11,392	846,199
1972	8	20,200	35,434	136,712

Table III. Other Abundant Species

Month	Estimated No. of Fish Impinged[a] - Species and Year					
	Blueback Herring 1968	Spottail Shiner 1969	Bay Anchovy 1970	Atlantic Menhaden 1971	Brown Bullhead 1971	Blueback Herring 1972
Jan		2,962				
Feb		1,123				
Mar		837		0	52	
Apr	0	1,557		0	103	
May	701	29		0	12	73
Jun	716	9		0	97	295
Jul	795	41,509	79	0	619	29
Aug	5,632	3,477	14,591	0	20,129	29
Sep	12,620	1,423	1,098	626,716	6,123	229
Oct	20,349	4	6,578	136,257	2,321	704
Nov	899	25				87
Dec	2	91				0
Total	41,714	53,046	22,346	762,973	29,456	1,446

[a]A zero indicates count made but no specimen obtained, whereas a blank indicates no count made.

CONNECTICUT YANKEE - HADDAM NECK (N)

FISH IMPINGEMENT DATA

MONTHLY ESTIMATES

ALL SPECIES

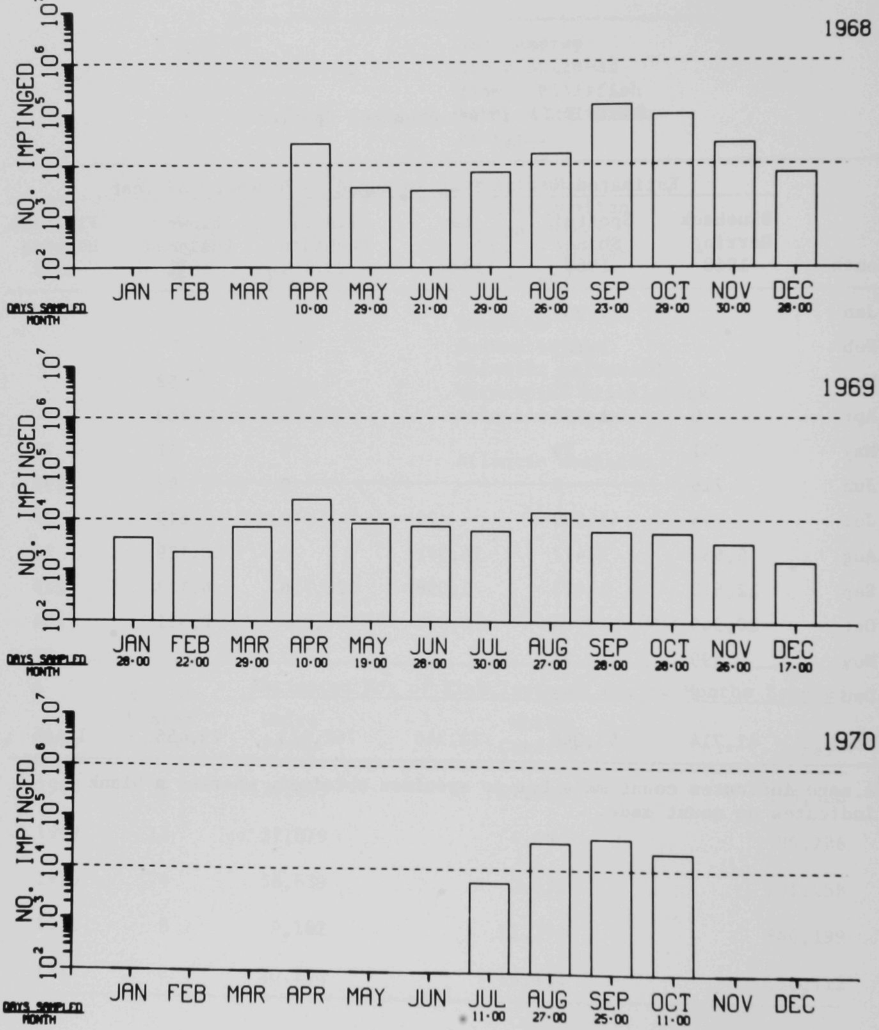


Fig. H1. Impingement Estimates.

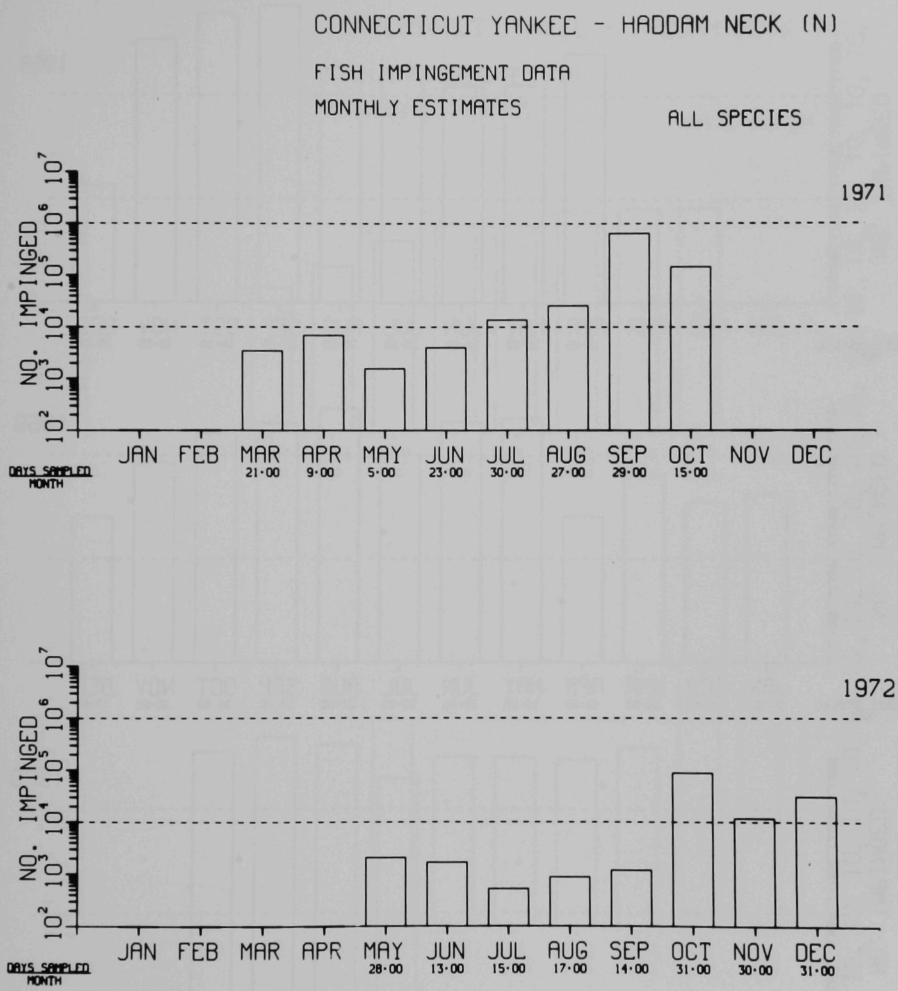


Fig. H2. Impingement Estimates.

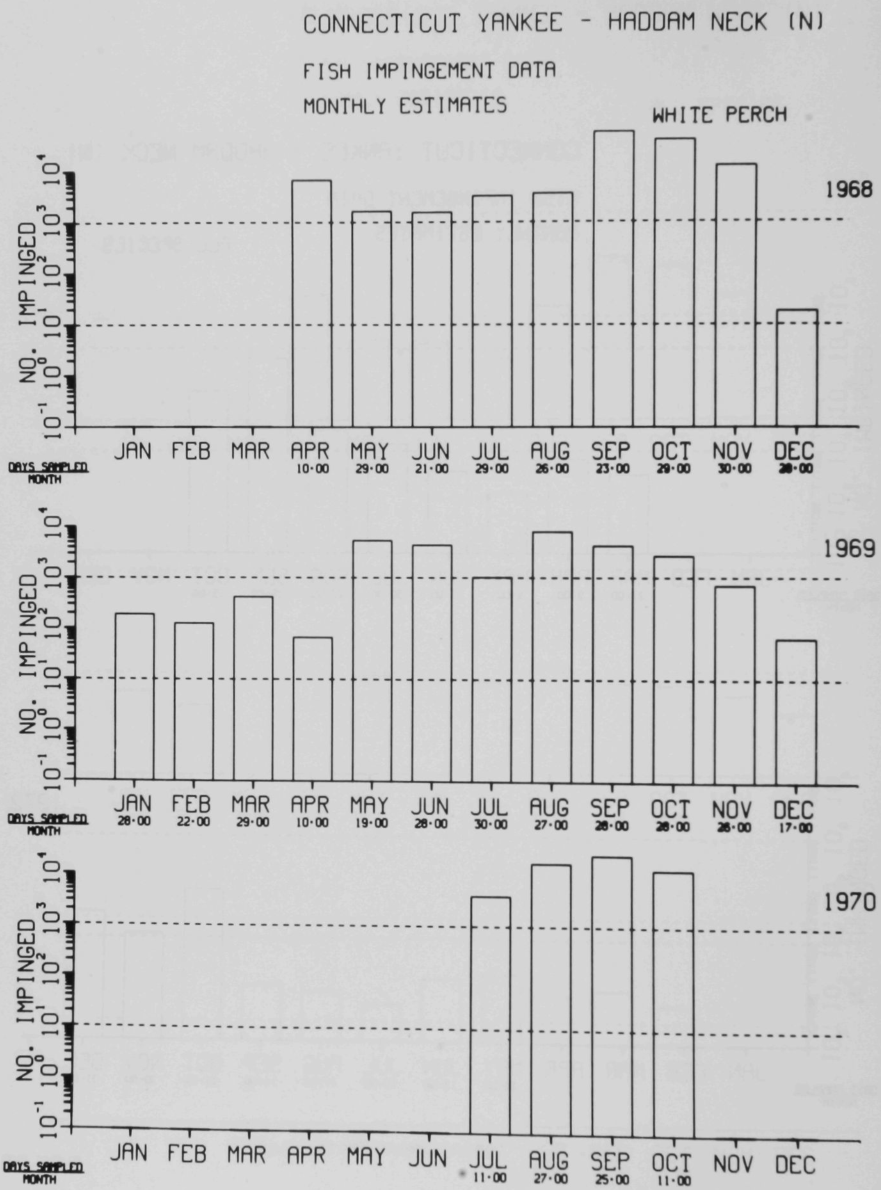


Fig. H3. Impingement Estimates.

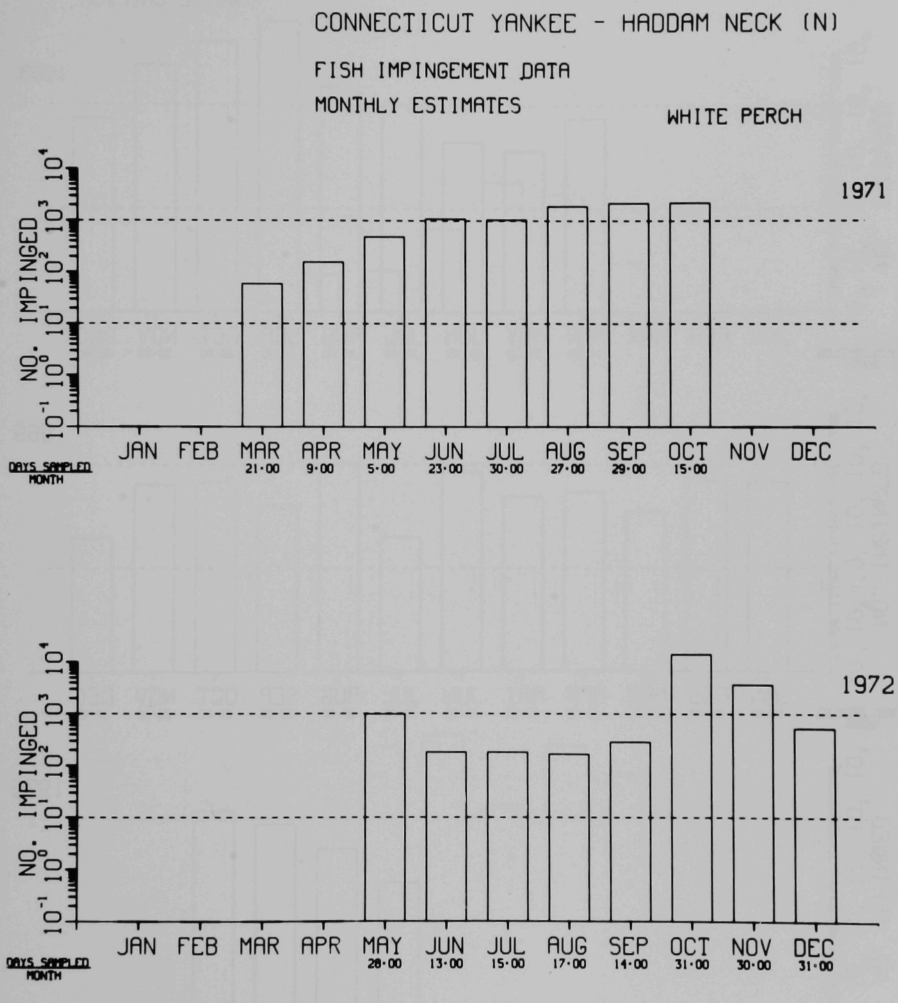


Fig. H4. Impingement Estimates.

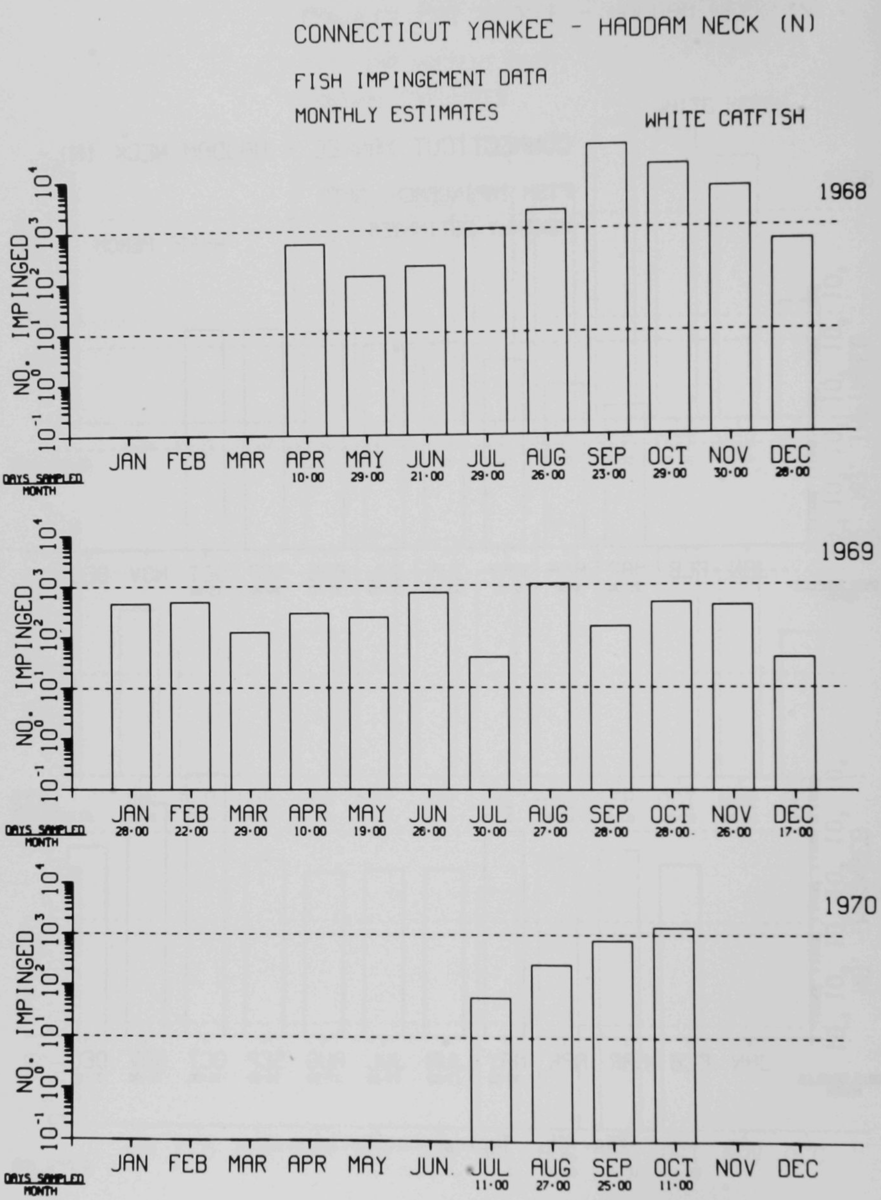
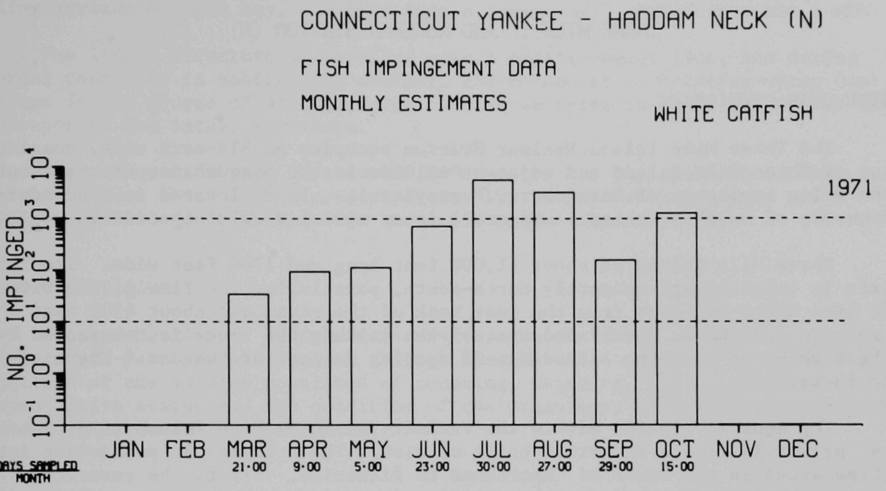


Fig. H5. Impingement Estimates.



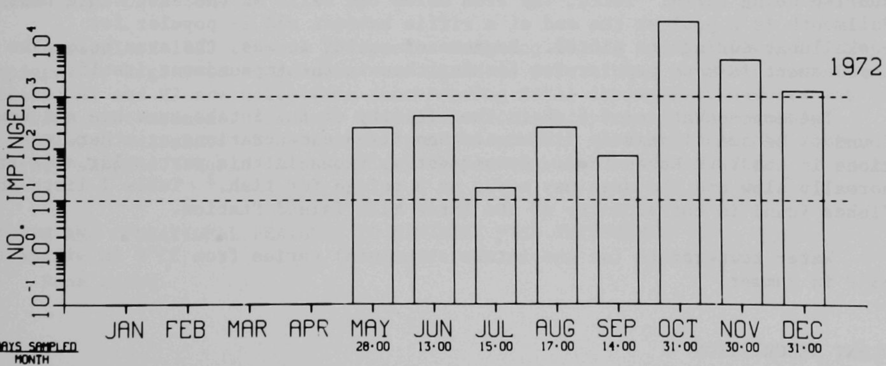


Fig. H6. Impingement Estimates.

THREE MILE ISLAND NUCLEAR STATION (N)

SITE CHARACTERISTICS

The Three Mile Island Nuclear Station occupies an 814-acre site, consisting of Three Mile Island and adjacent islands in the Susquehanna River, about ten miles southeast of Harrisburg, Pennsylvania. It is located in Londonderry Township of Dauphin County.[1] Figure 1 is an aerial view of the site.

Three Mile Island is about 11,000 feet long and 1700 feet wide. Its long axis is oriented approximately north-south, paralleling the flow of the river. It lies about 900 feet from the east bank of the river and about 6500 feet from the west bank. South and east of the island, the river is transected by the York Haven Dam, the island itself serving as part of the dam. There are no locks.

The aquatic habitat within the vicinity of Three Mile Island is of interest primarily from a fisheries point of view. The area may be subdivided into three areas on the basis of importance to fisheries. First, the reservoir above York Haven Dam between the island and the east bank of the river is not fished very much except in the fall when smallmouth bass may be taken; as a stream habitat, it is a mud-bottom pool. Second, the area southwest of Three Mile Island just above the dam is also a mud-bottom pool and is most popular, with muskellunge, smallmouth bass, largemouth bass, rock bass, and redbreast sunfish being taken. Third, the area below the falls on the east shore near Fallmouth is a pool at the end of a riffle habitat and is popular for muskellunge during the winter. Because of easier access, the area below the impoundment is more popular for fishing than is the impoundment itself.

The concentration of fish in the vicinity of the intake area has not been found to be quantitatively different than fish concentrations at other locations in the York Haven Pool. Consequently, flows in this particular area are normally slow and the area may serve as a refuge for fish.[2] Table I lists the fishes found in the vicinity of the Three Mile Island Station.

Water temperature (at the intake structure) varies from 33°F in winter to 85°F in summer.

PLANT DESCRIPTION

The Three Mile Island Nuclear Station consists of two pressurized water reactor units, the second of which is not operational. Unit 1 has a maximum electrical output of 871 MWe. Two 370-foot-high hyperbolic natural-draft cooling towers are utilized to dissipate the waste heat from the closed-cycle cooling system.

INTAKE DESIGN AND OPERATION

Upon entering the intake structure, the water passes under a skimmer wall that has trash bars with two-foot vertical spacings. From here the water passes through three individual intake bays, through the trash racks and traveling screens of each bay, and then into a common well that serves the pumps.

The intake structure is provided with a deicing-water line, and during normal operation in subfreezing weather, the condenser circulating-water discharge is the source of deicing water. Water velocity is about 0.2 fps at the entrance to the intake structure.

The makeup flow rate is about 27,000 gpm for the one operational unit, which includes about 10,000 gpm evaporated by the two cooling towers and a minimum of 2000 gpm blowdown from the cooling-tower basins.

IMPINGEMENT SAMPLING

Twenty-one 24-hour impingement surveys were conducted semimonthly beginning in mid-February and running through December 1974 at the Unit 1 intake.[3] Analysis of the samples consisted of counting, weighing, and determining the reproductive status and the condition of the organisms, as well as identifying them to the lowest feasible taxon.

DATA AVAILABILITY

Impingement data are available from mid-February through December 1974.

IMPINGEMENT DATA SUMMARY

A total of 1222 fish of 25 species weighing 1930 g (4.25 lb) was impinged.[3] Eighty-seven percent were dead and were either young or juvenile. Figures H1 and H2 are histograms representing total impingement numbers for the four most abundant species, as well as for all species. The monthly totals were calculated by extrapolating the numbers obtained from the semimonthly samples. Table II summarizes the impingement study results.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCES

1. "Final Environmental Statement, Three Mile Island Nuclear Station Units 1 and 2." USAEC Directorate of Licensing. Docket Nos. 50-289 and 50-320. December 1972.

2. Communication with R. M. Klingaman of Metropolitan Edison Company. 17 October 1975.

3. Potter, W. A. et al. "An Ecological Study of the Susquehanna River in the Vicinity of Three Mile Island Nuclear Station - Annual Report for 1974." Ichthyological Associates, Inc., New York. 1975.

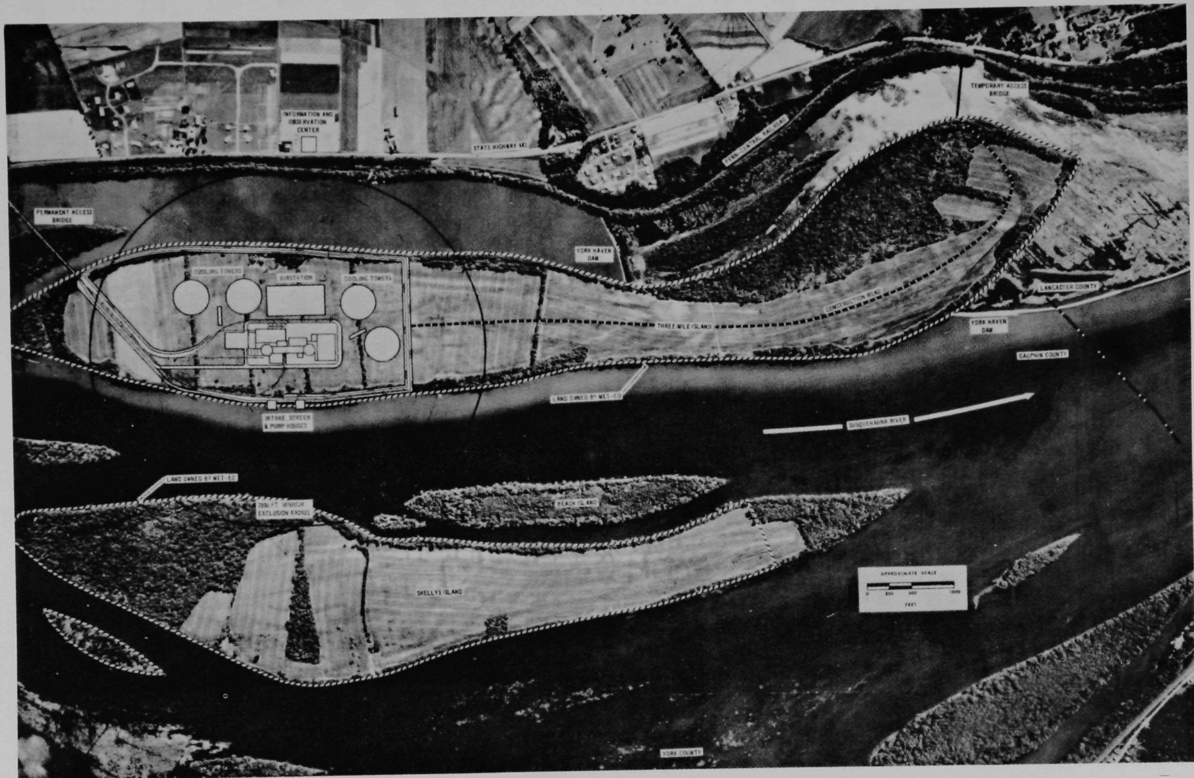


Fig. 1. Aerial View of the Site.

Table I. Fishes in the Station Vicinity

Bowfin	Yellow bullhead
Brown trout	Brown bullhead
Muskellunge	Margined madtom
Carp	American eel
Goldfish	Smallmouth bass
Golden shiner	Largemouth bass
Creek chub	Green sunfish
Fallfish	Pumpkinseed
River chub	Redbreast sunfish
Blacknose dace	Bluegill
Common shiner	Bluespotted sunfish
Spotfin shiner	Rock bass
Spottail shiner	Black crappie
Bluntnose minnow	White crappie
Quillback	Walleye
Shorthead redhorse	Yellow perch
White sucker	Johnny darter
Northern hog sucker	Tessellated darter
Channel catfish	
White catfish	

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled				
		Spottail Shiner	Tessellated Darter	Spotfin Shiner	Channel Catfish	Total
1974	10.5	1,562	8,216	2,842	2,765	22,229

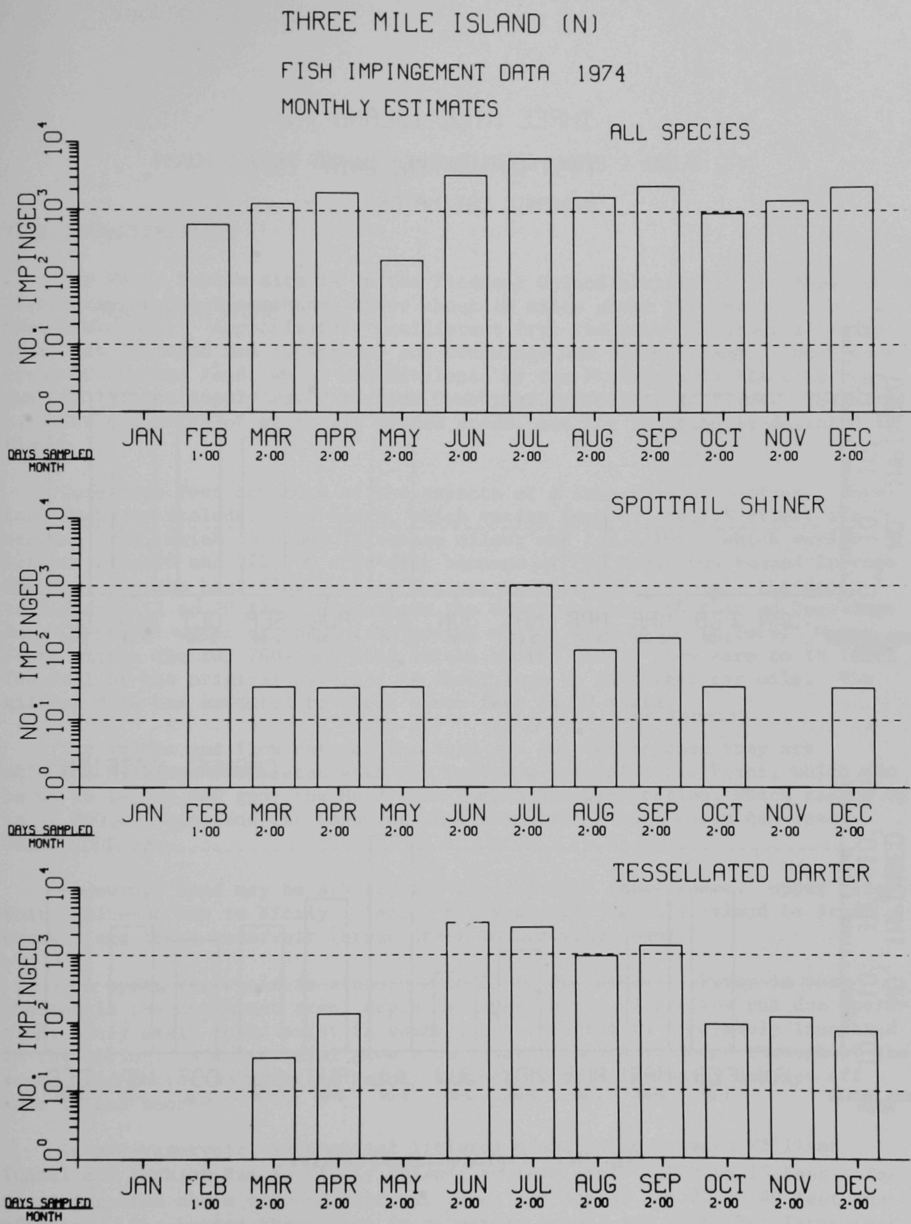


Fig. H1. Impingement Estimates.

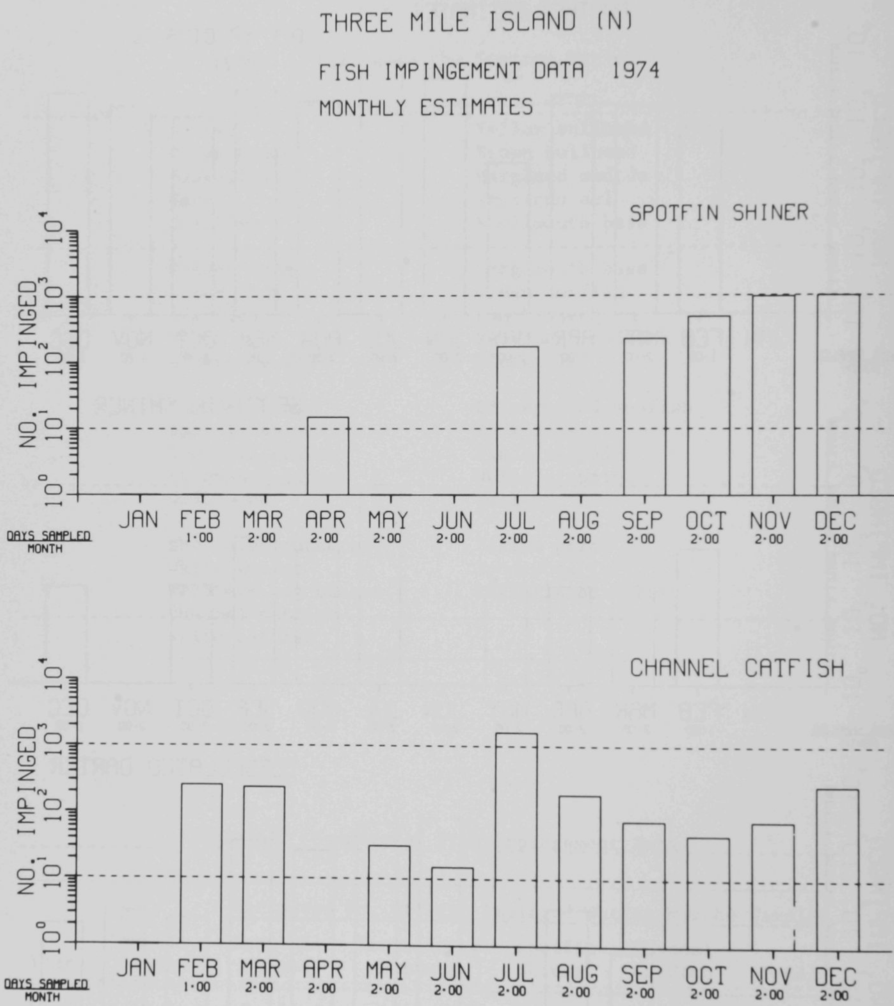


Fig. H2. Impingement Estimates.

PEACH BOTTOM ATOMIC POWER STATION UNITS 2 AND 3 (N)

SITE CHARACTERISTICS

The Peach Bottom site is in the Piedmont Upland section of the Appalachian Highlands, on the Susquehanna River about 18 miles above its entrance to Chesapeake Bay.[1] Approximately equidistant from the site and about 14 miles apart are Holtwood Dam (upstream) and Conowingo Dam (downstream). These dams create Conowingo Pond, which was developed by the Philadelphia Electric company in 1928 to supply water for the Conowingo Hydroelectric Plant. The site occupies 620 acres of generally wooded areas, and its location is depicted in Figure 1.

Conowingo Pond has more of the aspects of a lake than of a river. Physical features include: its width, which varies from 0.5 to 1.5 miles; its surface area, which is about 14 square miles; and its volume, which varies between 240,000 and 322,000 acre-feet because of the Muddy Run Pumped Storage Station. In the high-flow shallow upriver portions of the pond, the depth varies from 12 to 20 feet; downstream the depth reaches 100 feet at Conowingo Dam. Depth of water at the intake portal varies from 16 to 18 feet. Water depth within the two 700-foot-long intake basins varies from zero to 18 feet. The fall of the original riverbed is about four to five feet per mile. The silting rate has amounted to about seven feet in 20 years.

The volume and flow rate of the lake are complex because they are affected by flows associated with the Holtwood Hydroelectric Plant, which can be up to 14,000,000 gpm; the Muddy Run Pumped Storage Station, which can be up to 12,000,000 gpm; and the Conowingo Hydroelectric Plant, which can reach 38,000,000 gpm.

Conowingo Pond may be arbitrarily divided into three zones: upper reservoir (Holtwood Dam to Sicily Island), mid-reservoir (Sicily Island to Broad Creek), and lower reservoir (Broad Creek to Conowingo Dam).

The upper reservoir is studded with 25 to 30 islands. Water is very shallow in the northwest area; depth is dependent on river flow and dam operation. Only small ponds exist in summer, but the area is completely inundated in the spring. A substantial growth of aquatic plants is found throughout the area. The bottom material is mainly bedrock, with a few sandy beaches off some island shores.

In mid-reservoir, substantial littoral areas exist between Williams Tunnel and Burkins Run to Sicily Island; average depth is 10 to 15 feet. The remaining area has a reduced littoral zone, and depths are 20 to 40 feet just offshore. The bottom throughout is primarily gravel and silt, but large rocks and boulders are found along the shore.

The lower reservoir has a steep-sided basin with a reduced littoral zone. Water depths increase from 40 to 90 feet toward the dam over a distance of five to six miles. A major tributary stream enters on the east shore, forming a small cove. Three prominent coves occur on the west shore. The bottom is covered by numerous obstructions, e.g. trees and foundations of buildings that were present before impoundment in 1928.

Table I is a list of fish species collected in Conowingo Pond.

PLANT DESCRIPTION

Units 2 and 3 of the Peach Bottom Atomic Power Station employ identical boiling water reactors to produce a total of 2130 MWe. A "stretch" power level of 2226 MWe is anticipated at a future date. The exhaust steam is cooled by a once-through flow of water obtained from and discharged to the Susquehanna River and also by forced-draft cooling towers when needed.

INTAKE DESIGN AND OPERATION

The condensers for Units 2 and 3 are cooled in winter by a once-through flow of water from Conowingo Pond. During full operation of these units, a total flow of 1,500,000 gpm is required. Water is circulated by three 250,000-gpm pumps per unit.

Cooling water is withdrawn through an intake portal 487 feet long and parallel to the pond. This portal contains 32 intake openings that are protected by vertical, painted-steel trash bars 1/4 inch thick and about three inches wide, spaced 3-1/2 inches apart, and parallel to the intake-water flow. Thus, the width of the openings between the bars is 3-1/4 inches.

About 40 feet behind the trash-bar intake portals are 24 vertical traveling screens of 3/8-inch mesh. These screens are contained in structures that extend 408 feet parallel to the pond. The locations are shown in Figure 2. The total intake area was designed to be large enough to allow a velocity through the screens of 0.75 fps or less at reservoir levels down to the 104.5-foot elevation, the lowest pond level normally attained.

The cooling water enters two separate intake basins, each about 700 by 200 feet, and travels the 700-foot length to the pump-intake facility. There are six pump intakes, three in each basin. The pump intakes are protected by vertical traveling screens. These screens are of the same 3/8-inch mesh as those in the external structure.

The cooling water is discharged into Conowingo Pond, going first to an intermediate pond from which it is directed at five to eight fps down a 4700-foot canal to a subsurface discharge port. In summer, 57% of the water may be diverted through forced-draft helper (open-cycle) cooling towers for preliminary cooling before subsequent discharge to the canal and reservoir.

IMPINGEMENT SAMPLING

Sampling was conducted for 12-hour periods for both Units 2 and 3.[2] The number, size, and species of fish impinged on the twelve outer and three inner vertical traveling screens at Unit 2 were determined in November and December 1973 during 16 such periods. During 1974 sampling took place, at the outer screens only, for 44 periods from January through June and 61 periods from July through December. In December 1974 sampling was begun at Unit 3 and was conducted for five periods at the outer screens only. From January through June 1975 sampling was conducted for 20 periods, at the outer screens only, at both Units 2 and 3.

DATA AVAILABILITY

Data are available for Unit 2 for November and December 1973, all of 1974, and January, February, March, and June 1975. For Unit 3, data are available for December 1974 and January through June 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H8 are histograms representing total numbers of the three most abundant species as well as all species impinged at Units 2 and 3. These totals are summarized in Table II.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCES

1. "Final Environmental Statement, Peach Bottom Atomic Power Station Units 2 and 3." USAEC Directorate of Licensing. Docket Nos. 50-277 and 50-278. April 1973.

2. "Post-Operational Reports on the Ecology of Conowingo Pond." Nos. 1 through 4. Ichthyological Associates, Inc., Drumore, Pennsylvania. 1973-1975.

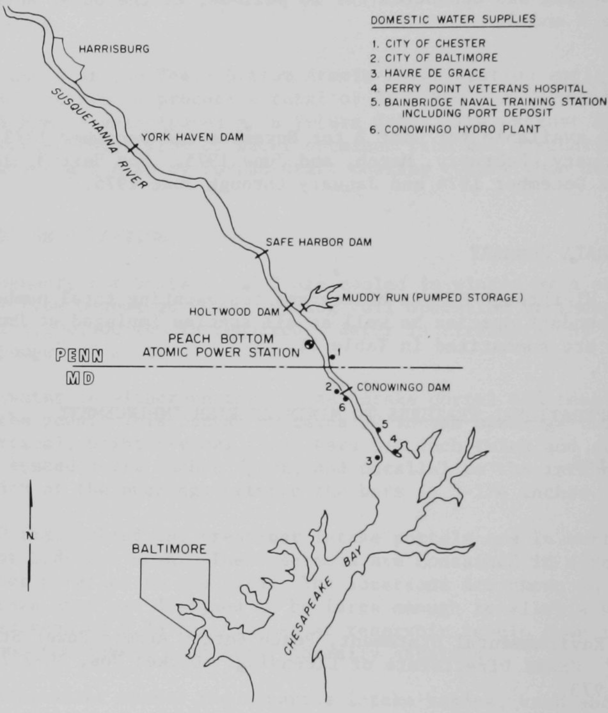


Fig. 1. Site Location.

Fig. 2. The Station Showing Intakes and Discharge.

Table I. Fishes of Conowingo Pond

American eel	Quillback
Brown trout	White sucker
Brook trout	Northern hog sucker
Chain pickerel	Shorthead redhorse
Muskellunge	White catfish
Stoneroller	Yellow bullhead
Goldfish	Brown bullhead
Rosyside dace	Channel catfish
Carp	Margined madtom
Silverjaw minnow	Banded killifish
Cutlips minnow	Mummichog
River chub	Rock bass
Golden shiner	Redbreast sunfish
Comely shiner	Green sunfish
Common shiner	Pumpkinseed
Spottail shiner	Bluegill
Swallowtail shiner	Smallmouth bass
Rosyface shiner	Largemouth bass
Spotfin shiner	White crappie
Bluntnose minnow	Black crappie
Fathead minnow	Tessellated darter
Blacknose dace	Yellow perch
Longnose dace	Logperch
Creek chub	Shield darter
Fallfish	Walleye

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Bluegill	White Crappie	Channel Catfish	Total
Unit 2					
1973	2	10,085	7,484	6,269	25,834
1974	12	1,868	7,250	25,621	38,074
1975	4	1,950	759	8,464	12,268
Unit 3					
1974	1	3,038	6,696	5,322	16,471
1975	6	9,433	1,778	31,292	48,384

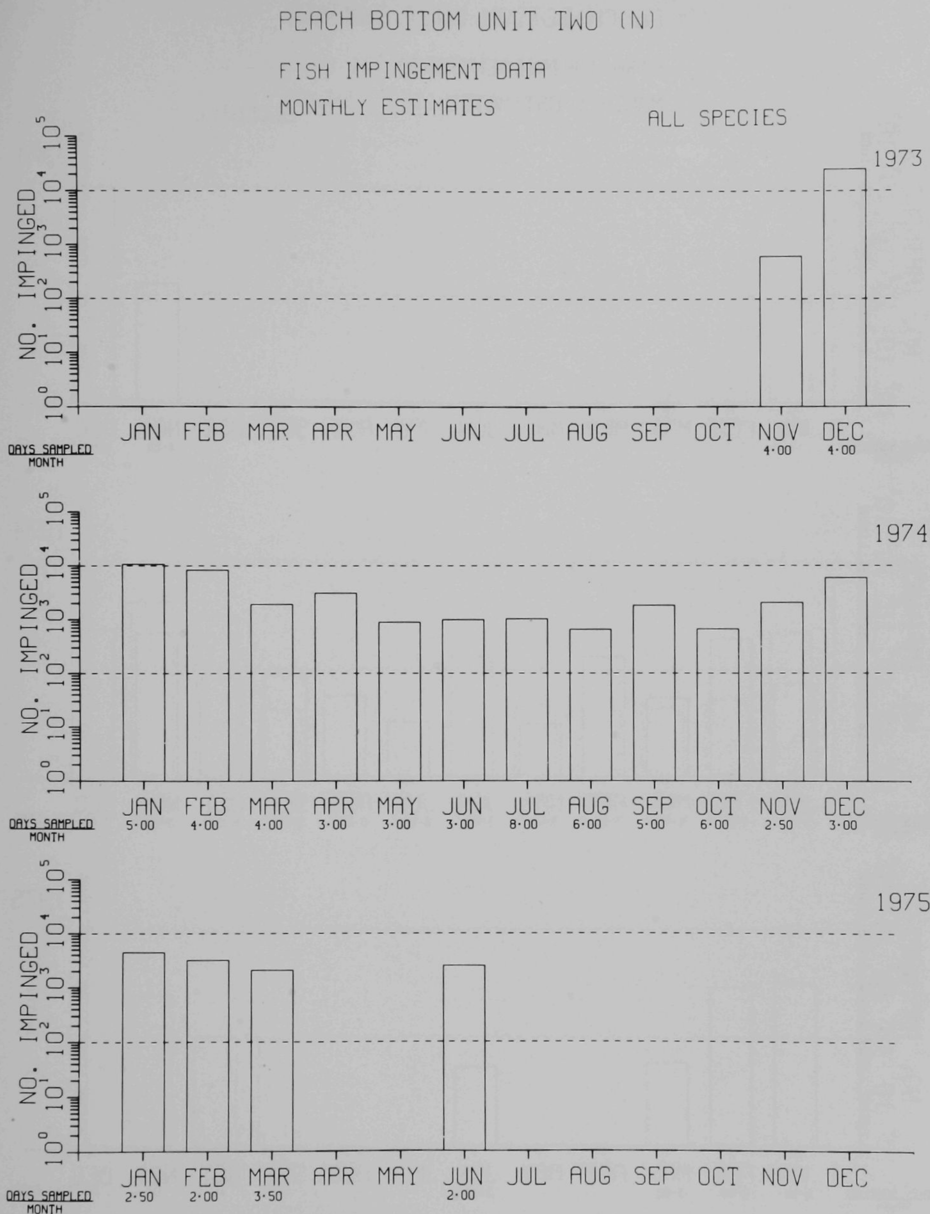


Fig. H1. Impingement Estimates.

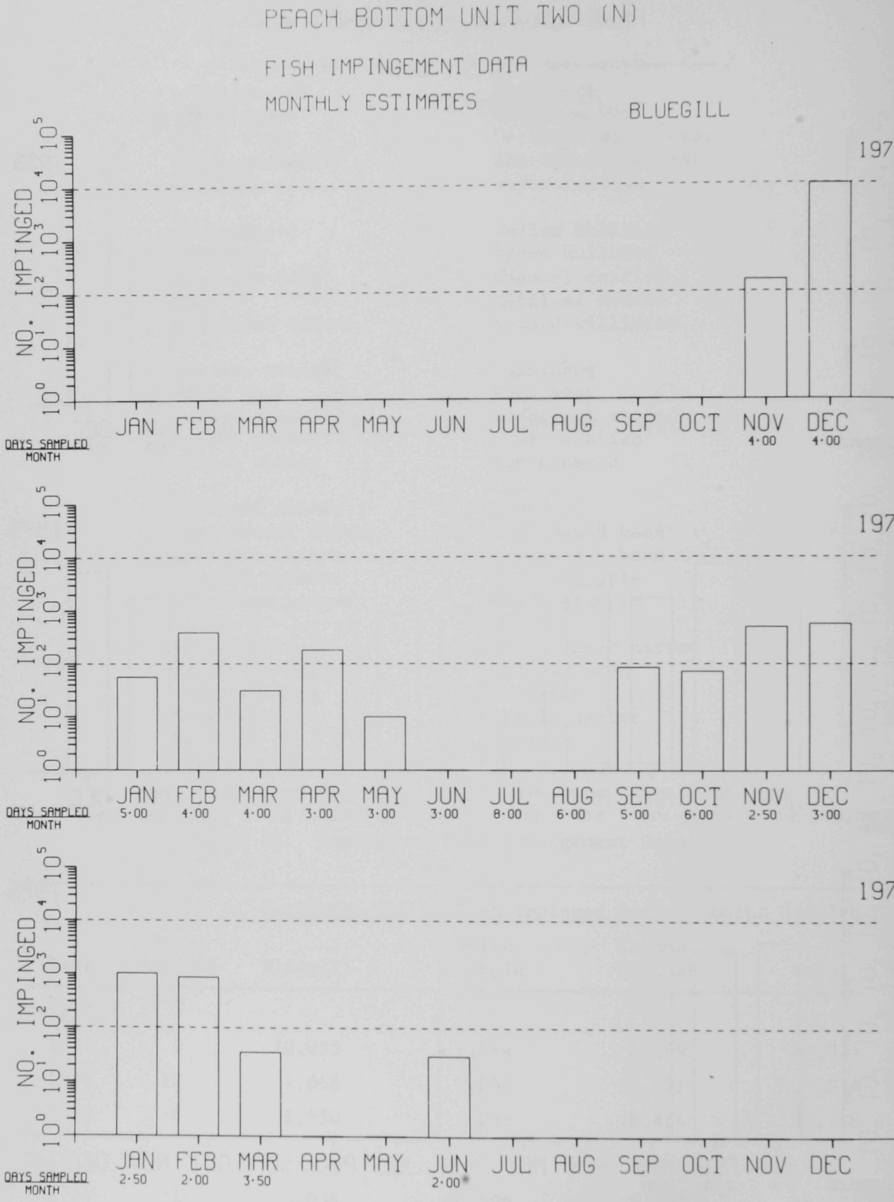


Fig. H2. Impingement Estimates.

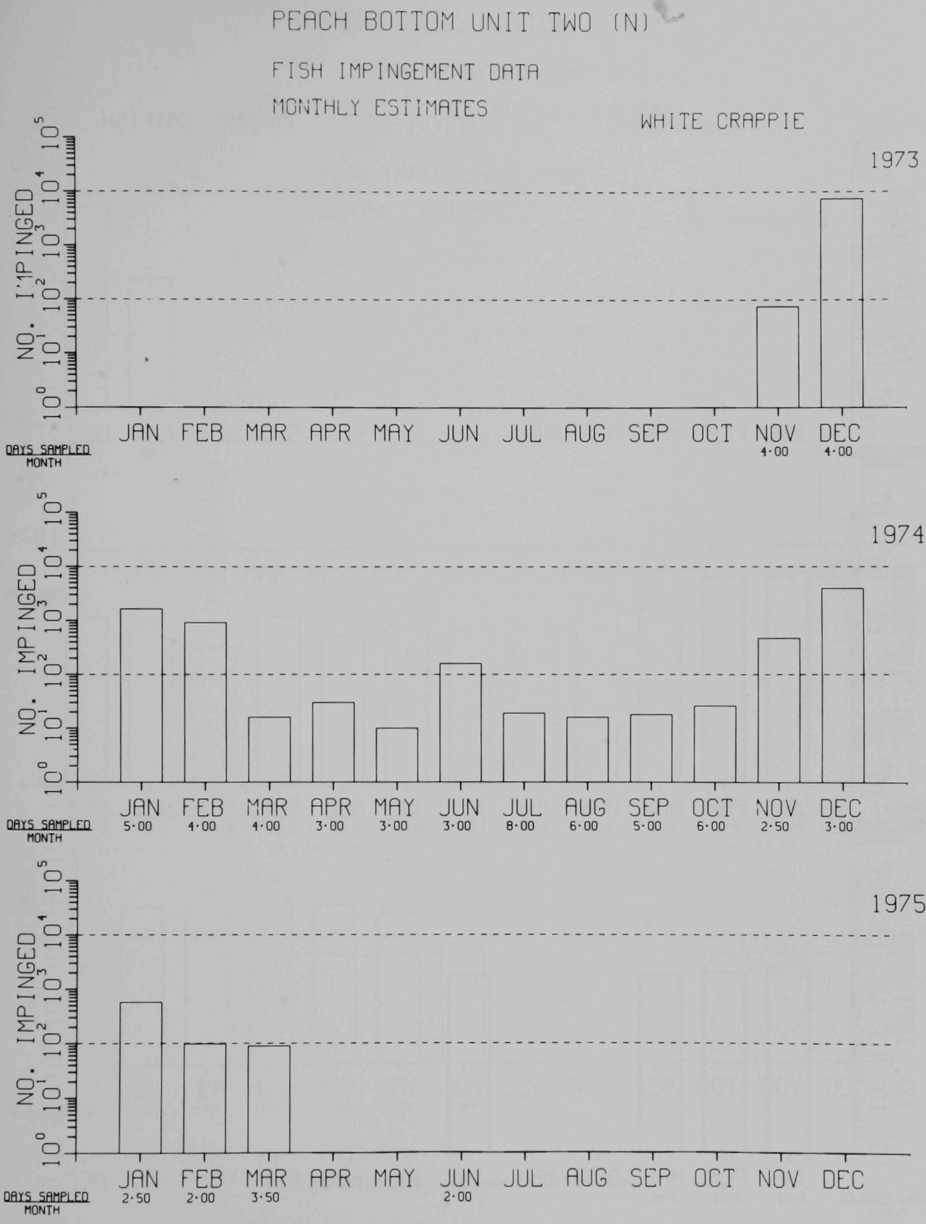


Fig. H3. Impingement Estimates.

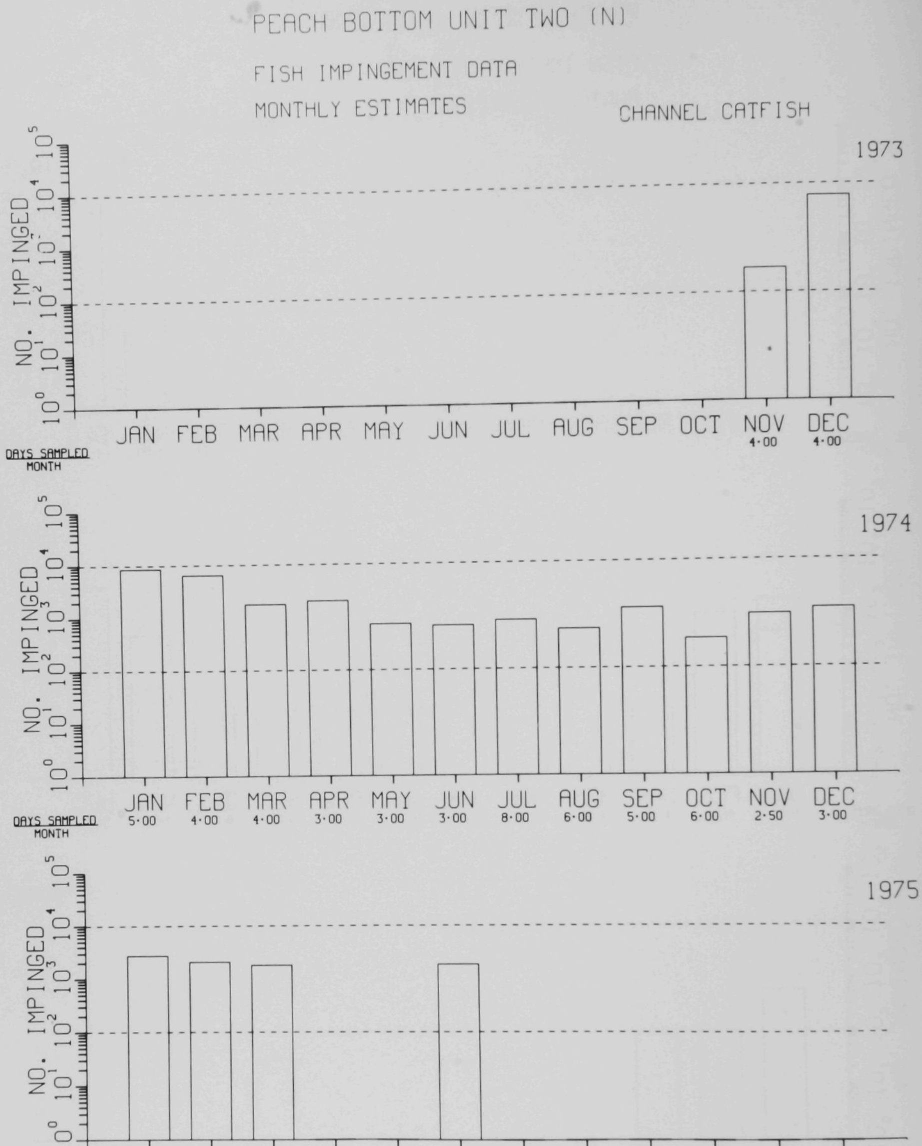


Fig. H4. Impingement Estimates.

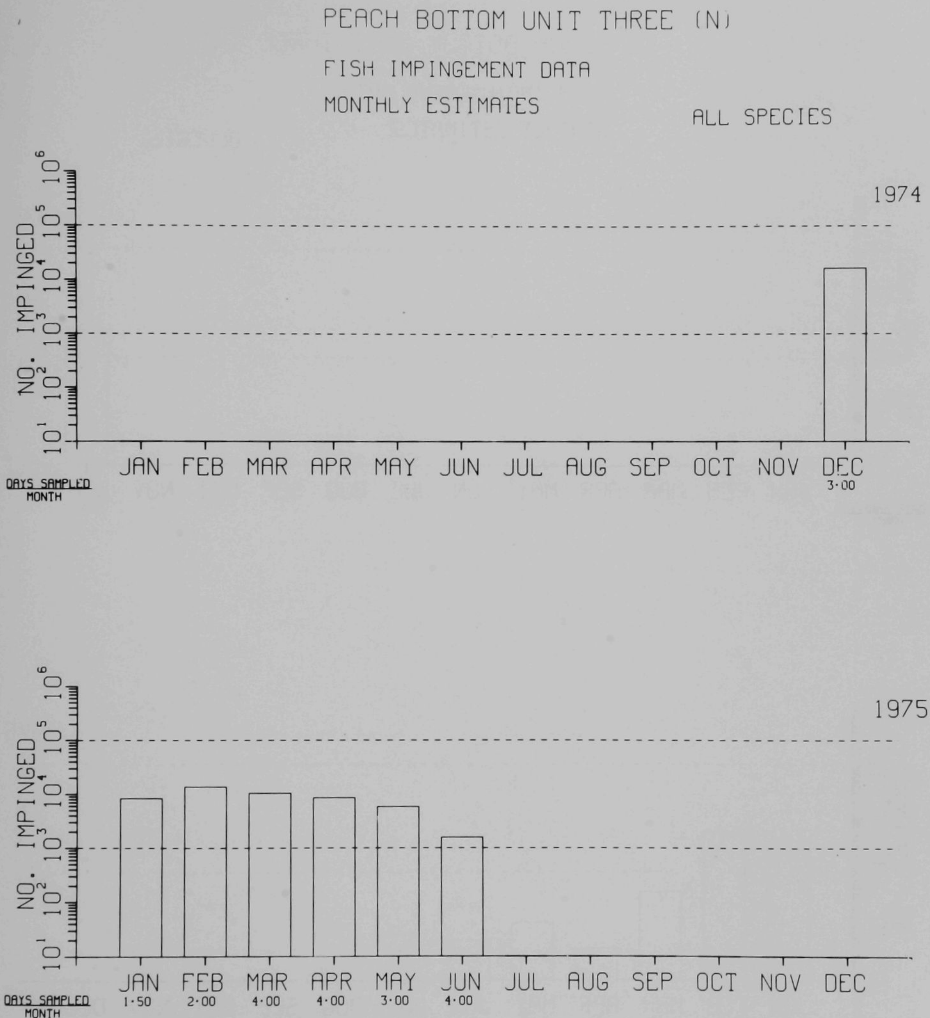


Fig. H5. Impingement Estimates.

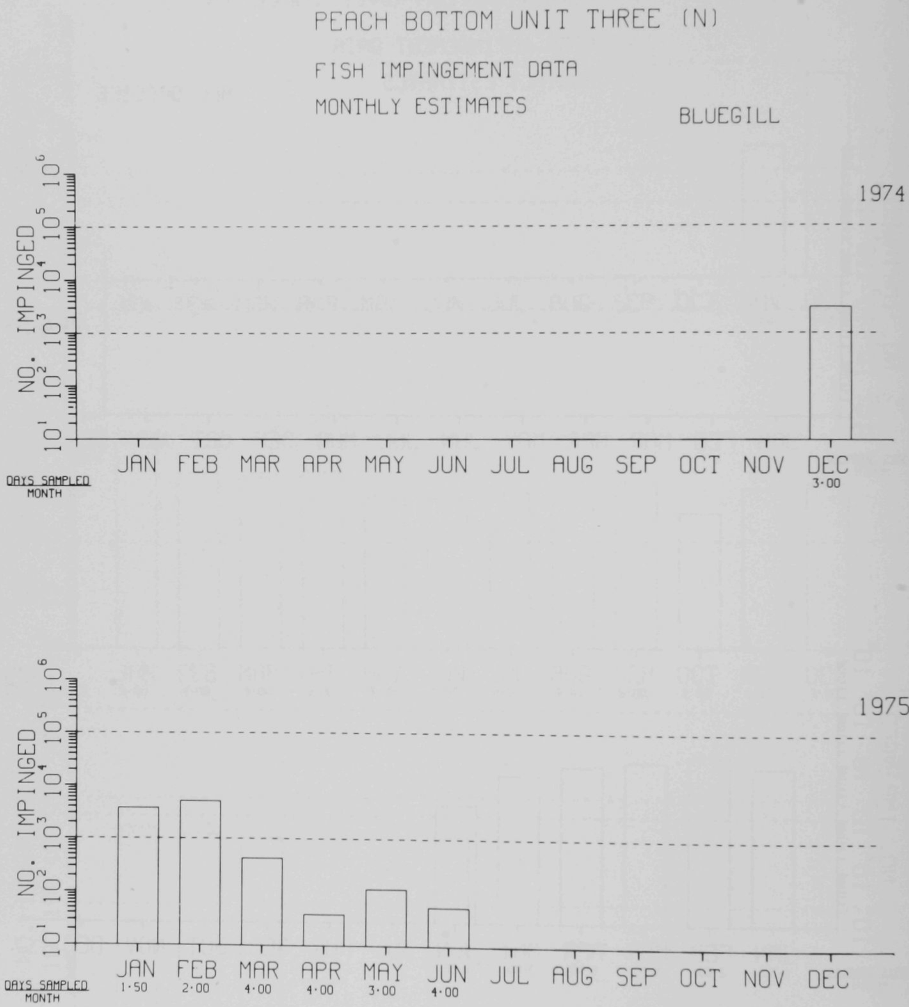


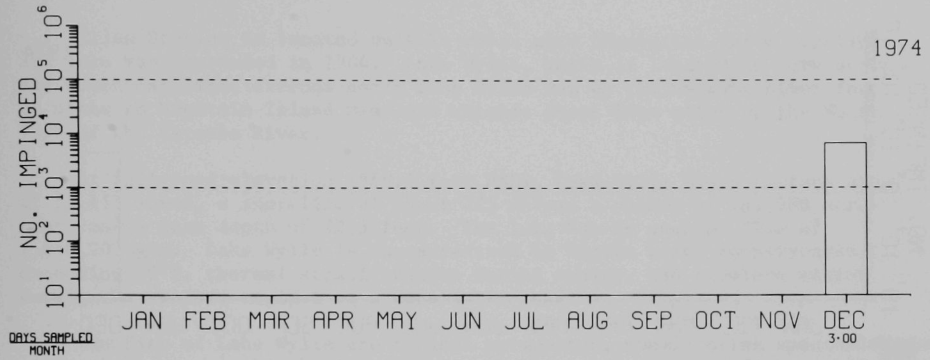
Fig. H6. Impingement Estimates.

PEACH BOTTOM UNIT THREE (N)

FISH IMPINGEMENT DATA

MONTHLY ESTIMATES

WHITE CRAPPIE



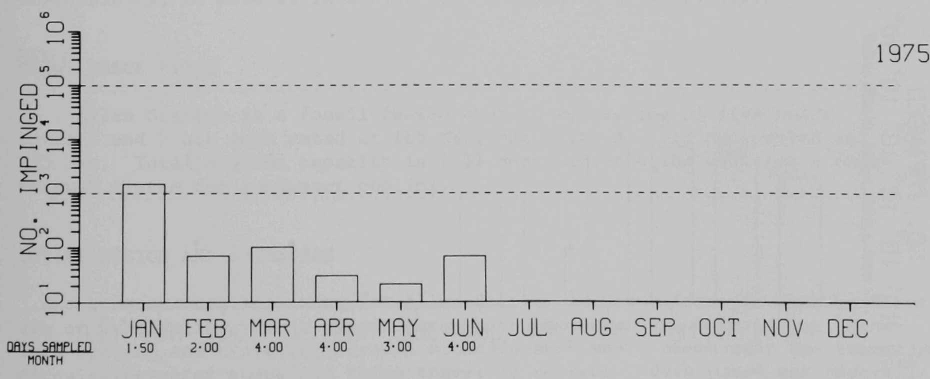


Fig. H7. Impingement Estimates.

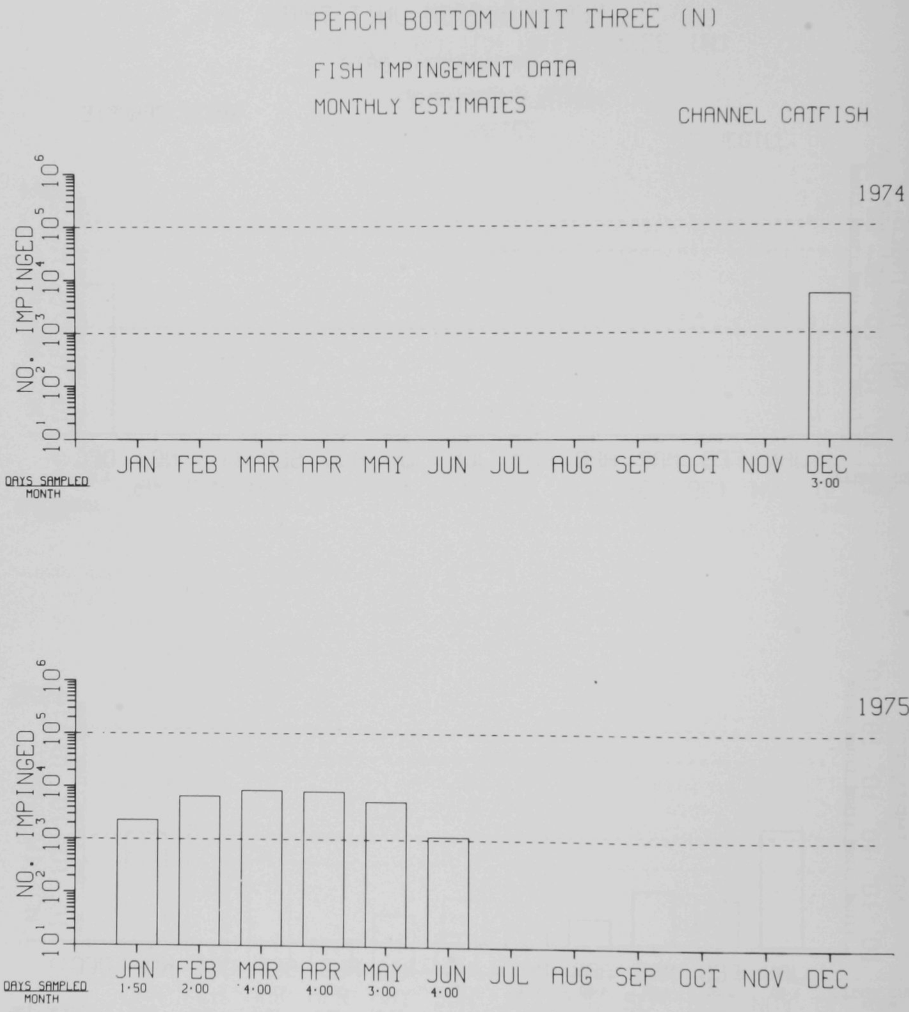


Fig. H8. Impingement Estimates.

ALLEN STATION (F)

SITE CHARACTERISTICS

Allen Station is located on Lake Wylie near Charlotte, North Carolina. The lake was impounded in 1904. Lake Wylie, which is located in both North and South Carolina, extends north from Wylie Dam up the Catawba River for 28 miles to Mountain Island Dam, and extends about five miles up the South Fork of the Catawba River.

At full-pond elevation (569.4 feet MSL), Lake Wylie has a surface area of 12,455 acres, a shoreline of about 325 miles, a volume of 281,900 acre-feet, and a mean depth of 22.5 feet. The lake has an average flow of 1,840,207 gpm. Lake Wylie is characterized by winter water temperatures exceeding 39°F, thermal stratification during summer, and complete mixing during the winter, typical of a monomictic lake.[1]

The fish of Lake Wylie are typical warm-water, nonmigrating species that spawn wherever suitable habitat exists. Table I is a list of fishes collected from Lake Wylie.

The Catawba River at the station is about 1500 feet wide. The main channel, about 30 feet deep, is near the west shore about 400 feet east of the intake structure. The bottom, from the intake structure to the edge of the main channel, is more or less flat with a depth of about 15 feet.

PLANT DESCRIPTION

Allen Station is a fossil-fueled station consisting of five units. Units 1 and 2 are each rated at 165 MWe, and Units 3-5 are each rated at 275 MWe. Total station capacity is 1155 MWe. The station utilizes a once-through system for condenser cooling.

INTAKE DESIGN AND OPERATION

Condenser cooling water for Allen Station is drawn from the Catawba River arm of Lake Wylie. Water passes through trash racks with bars having three-inch spacing and traveling screens with 3/8-inch mesh. Each unit has two circulating-water pumps and three traveling screens. Both pumps are generally used during the summer when the unit is at full load, but only one pump is usually used during the winter or when the unit is at reduced load. Units 1 and 2 share a common cooling-water tunnel served by four pumps. Similarly, Units 3 and 4 share a tunnel and four pumps. Unit 5 has a separate tunnel and can operate with one or two pumps (Fig. 1). Table II gives condenser flow rates for the five units. Maximum total condenser flow rate for the entire station is 598,741 gpm. Intake velocities are given in Table III.

IMPINGEMENT SAMPLING

Samples of 24-hour duration were conducted every two to three weeks. The screens were rotated and washed prior to sampling. When numbers of fish were too large for individual measurement, subsampling was utilized. The total weight of fish was noted and a random subsample of 10 to 100 fish was taken. The fish in the subsample were weighed and measured separately. All fish collected were identified to species when possible, and were counted, weighed, and measured.[1]

DATA AVAILABILITY

Fish impingement data for Allen Station are available for 6 September 1973 through 20 August 1974.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing the three most abundant species as well as all species impinged at the station. These totals are summarized in Table IV.

Station operation was at capacity on 10 of the 24 sampling dates. Unit 3 was shut down on 20 November and 11 December 1973. Unit 4 was not operational on 5 March 1974. Units 1 and 2 were off line on 4 April 1974, and Unit 1 was still not operating by 16 April 1974. Unit 5 was shut down for repairs on 2 July 1974.

Collection periods were for only 16 hours instead of 24 hours on 11 December 1973 and 26 February 1974. This has been taken into account in extrapolating the monthly totals.

Intakes for Units 1 and 5 produced consistently higher quantities of entrapped fish and debris than did those for Units 2-4. This may reflect the higher intake volume of the pumps for Unit 5 and the outermost locations of the intakes for the two units.[1]

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCE

1. F. J. Krueger et al. "Screen Monitoring at Allen Station." Industrial Bio-Test Laboratories, Inc., Northbrook, Illinois.

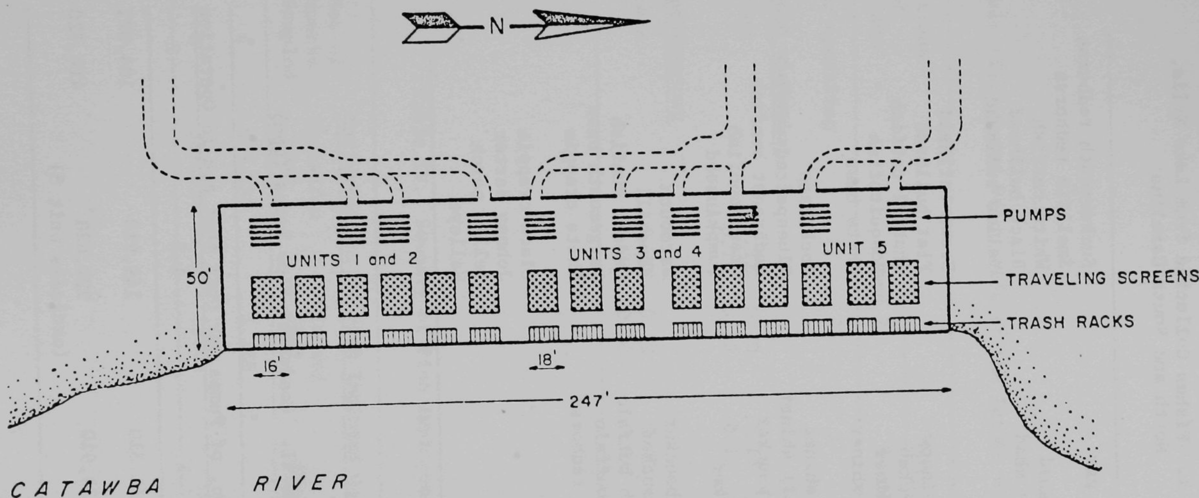


Fig. 1. Schematic Top View of the Intake Structure.

Table I. Fishes Collected from Lake Wylie, North and South Carolina

Longnose gar	Suckermouth redhorse
Bowfin	Smallfin redhorse
Gizzard shad	White catfish
Threadfin shad	Black bullhead
Goldfish	Yellow bullhead
Carp	Brown bullhead
Silvery minnow	Flat bullhead
Bluehead chub	Channel catfish
Golden shiner	Mosquitofish
Satinfin shiner	White bass
Spottail shiner	Rock bass
Swallowtail shiner	Bluespotted sunfish
River carpsucker	Redbreast sunfish
Quillback	Green sunfish
White sucker	Pumpkinseed
Creek chubsucker	Warmouth
Lake chubsucker	Bluegill
Smallmouth buffalo	Redear sunfish
Bigmouth buffalo	Largemouth bass
Shorthead redhorse	White crappie
	Black crappie
	Johnny darter
	Yellow perch
	Walleye

Table II. Condenser Flow Rates (gpm)

	No. of Pumps per Unit that Are in Operation		
Units	1	1.5	2
1 and 2	111,310	149,910	184,021
3-5	24,910	222,620 (excludes Unit 5)	414,720

Table III. Water Velocities at the Intake Structure (fps)

Conditions and Locations	Unit(s)					
	1 and 2		3 and 4		5	
No. of pumps operating	1	2	1	2	1	2
At full-pond elevation						
Trash rack	0.12	0.20	0.18	0.30	0.18	0.30
Screen	0.15	0.25	0.22	0.36	0.22	0.36
At maximum drawdown						
Trash rack	0.20	0.33	0.30	0.50	0.30	0.50
Screen	0.24	0.42	0.35	0.59	0.35	0.59

Table IV. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Threadfin Shad	Gizzard Shad	Bluegill	Total
1973	4	559,789	1,128	370	564,913
1974	8	327,836	1,156	3,447	335,379

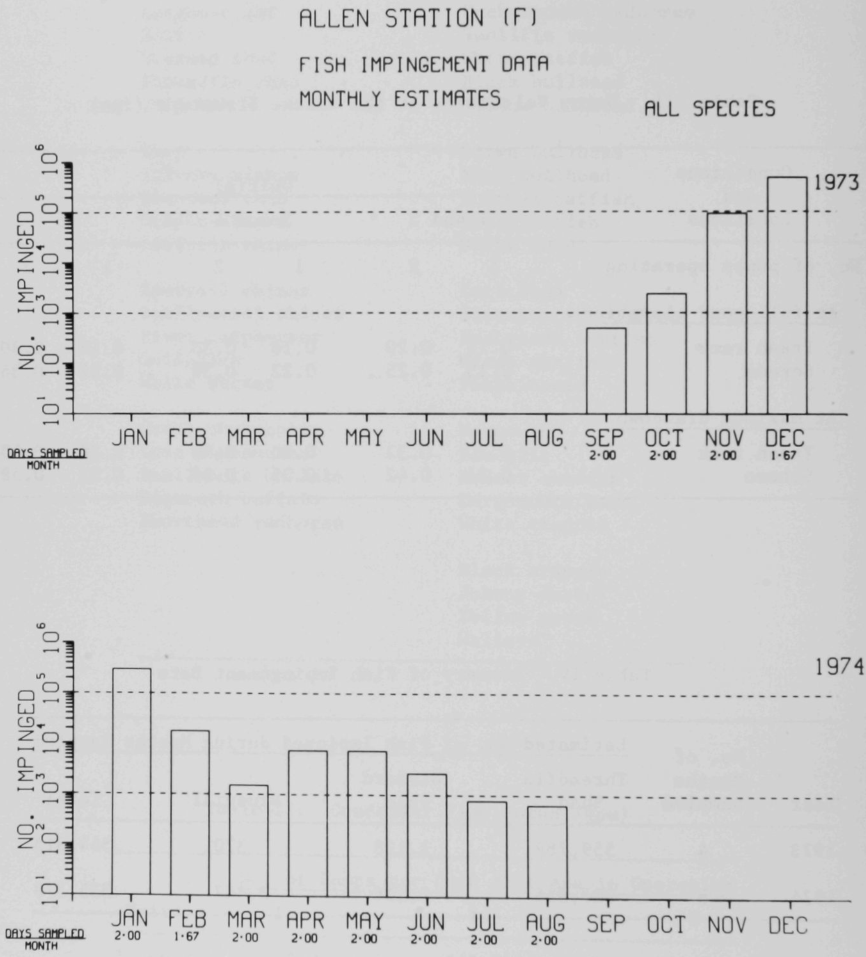
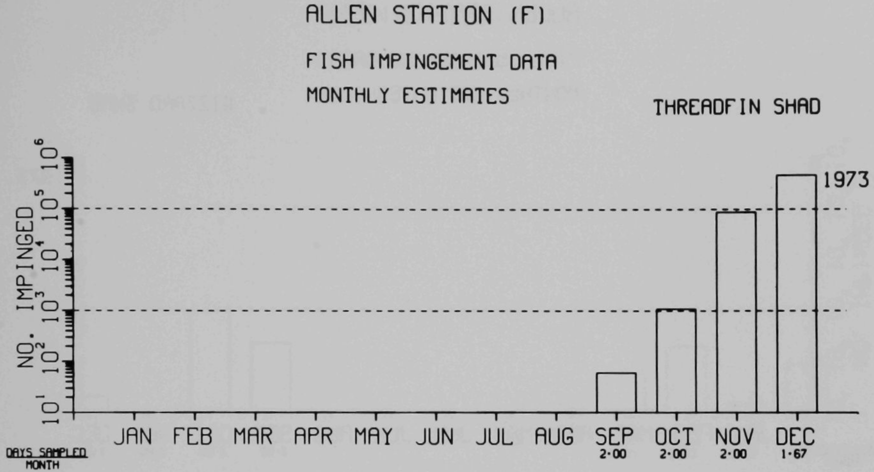


Fig. H1. Impingement Estimates.



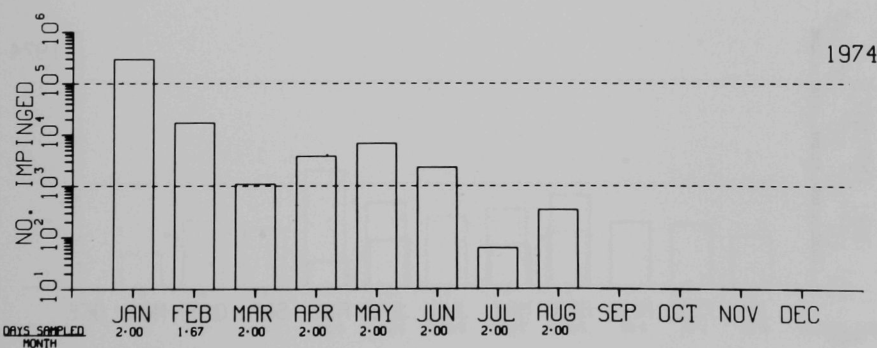


Fig. H2. Impingement Estimates.

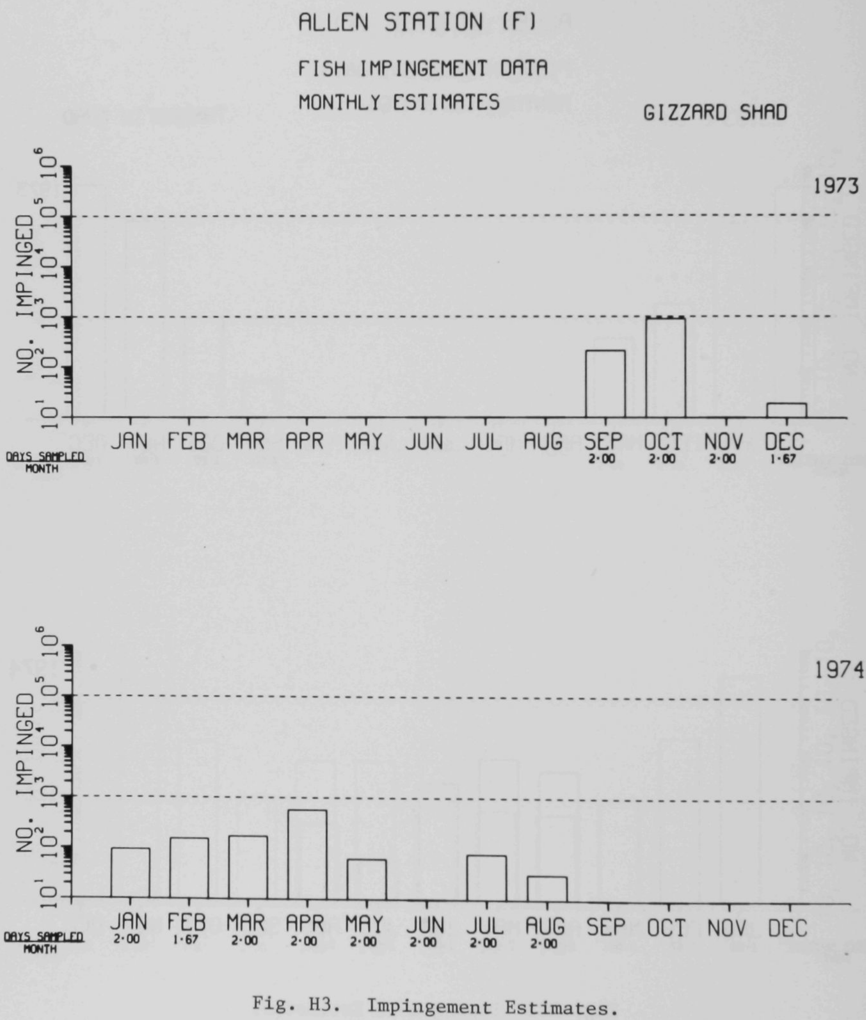


Fig. H3. Impingement Estimates.

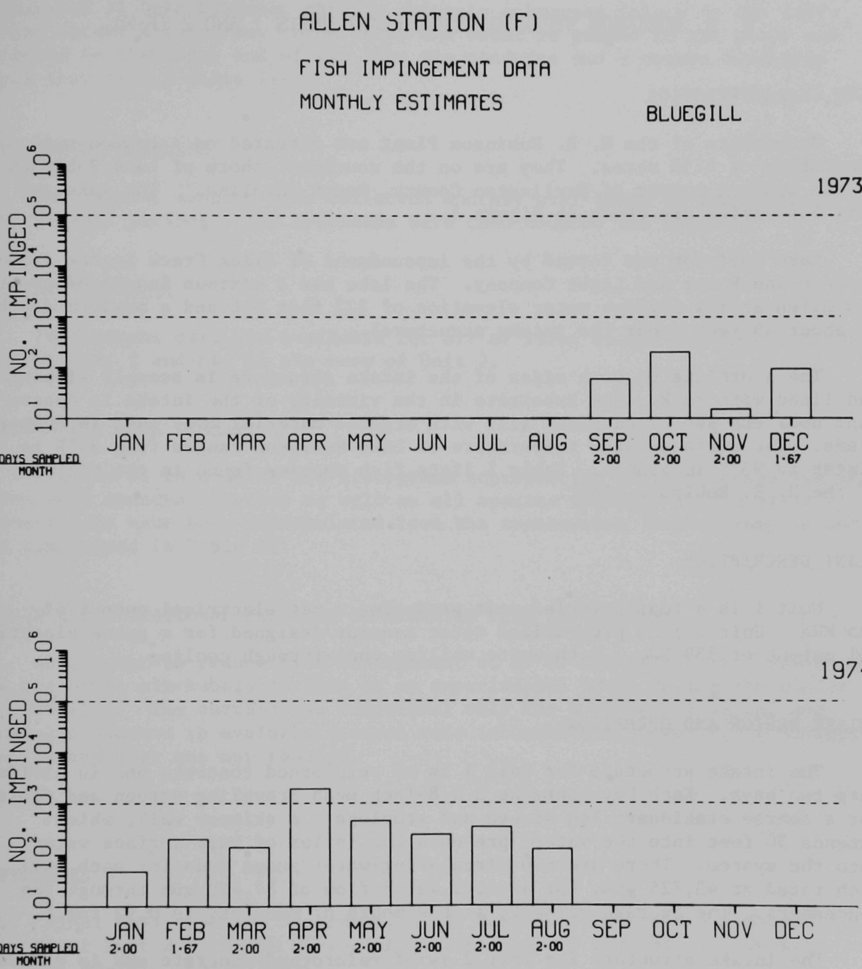


Fig. H4. Impingement Estimates.

H. B. ROBINSON STEAM-ELECTRIC PLANT UNITS 1 AND 2 (F-N)

SITE CHARACTERISTICS

Both units of the H. B. Robinson Plant are situated on a common site consisting of 4750 acres. They are on the southwest shore of Lake Robinson in the western corner of Darlington County, South Carolina.[1] The lake and site boundaries are shown in Figure 1.

Lake Robinson was formed by the impoundment of Black Creek in the 1950s by Carolina Power and Light Company. The lake has a maximum length of about 7.5 miles at its highest water elevation of 222 feet MSL and a maximum depth of about 45 feet (near the intake structure).

The shoreline on both sides of the intake structure is steeply sloping and lined with rock. The substrate in the vicinity of the intake is coarse sand near the shore and black silt with organic material over sand in deeper areas. The surface-water temperature of Lake Robinson ranges from 55°F in winter to 93°F in summer. Table I lists fish species found in the vicinity of the H. B. Robinson Plant.

PLANT DESCRIPTION

Unit 1 is a fossil-fueled unit producing a net electrical output of 185 MWe. Unit 2 is a pressurized water reactor designed for a gross electrical output of 739 MWe. Both units utilize once-through cooling.

INTAKE DESIGN AND OPERATION

The intake structure for Unit 1 is of reinforced concrete and is divided into two bays. Each bay contains a 3/8-inch mesh traveling screen and slots for a coarse stationary log screen and stoplogs. A skimmer wall, which extends 30 feet into the water, prevents the influx of warm surface water into the system. There are two circulating-water pumps (one for each bay) each rated at 43,725 gpm, for a total water flow of 87,450 gpm through the condensers. The average velocity at the mouth of each bay is 0.92 fps.[2]

The intake structure for Unit 2 is of reinforced concrete and is divided into three bays (Figs. 2 and 3). Each bay has a skimmer wall at the inlet, a 3/8-inch mesh traveling screen, and slots for a coarse stationary log screen and stoplogs. One condenser circulating-water pump is located in each bay. The three pumps each provide an average water flow of 160,700 gpm, for a total flow of 482,100 gpm through the condensers. At maximum flow, water velocity through the screens is about 2.1 fps. The screens are cleaned by a spray of water at 50 psi pressure. Trash removed from the screens is washed through a concrete trough to the storm-drain system, which empties into Black Creek below the dam.

Water for both units at the H. B. Robinson Plant is taken from the downstream end of Lake Robinson through separate submerged inlets to the individual intake structures. From here, the water is pumped to the plant and returned to the upper end of the lake via conduits and a common discharge canal that is 4.2 miles long.

IMPINGEMENT SAMPLING

Impingement samples were collected monthly over three or four consecutive 12-hour periods. The specimens were then counted and weighed.[3]

DATA AVAILABILITY

Impingement data are available for all of 1974, except for March in the case of Unit 1 and May in the case of Unit 2.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing monthly totals for the three most abundant species as well as all species impinged at the plant. These totals have been extrapolated from the consecutive 12-hour samples and are summarized in Table II.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

An attempt to reduce fish impingement at H. B. Robinson Unit 2 involved the use of an air-bubble curtain on an experimental basis during the winter of 1970-1971. The curtain was functional only for a three-day period and studies conducted to evaluate success were inconclusive; however, it appears that impingement was not reduced.

REFERENCES

1. "Final Environmental Statement, H. B. Robinson Nuclear Steam-Electric Plant Unit 2." USNRC Office of Nuclear Reactor Regulation. Docket No. 50-261. April 1975.

2. Personal communication with Buzz Bryson of Carolina Power and Light Company. 9 June 1976.

3. Personal communication with William T. Hogarth of Carolina Power and Light Company. 9 June 1976.

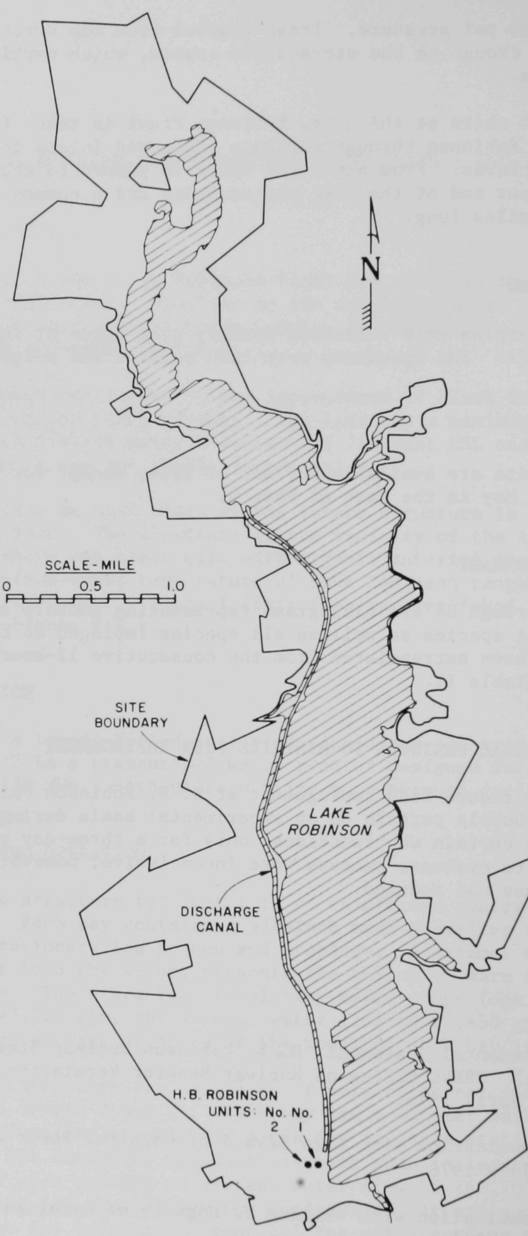


Fig. 1. Lake Robinson and Site Boundaries.

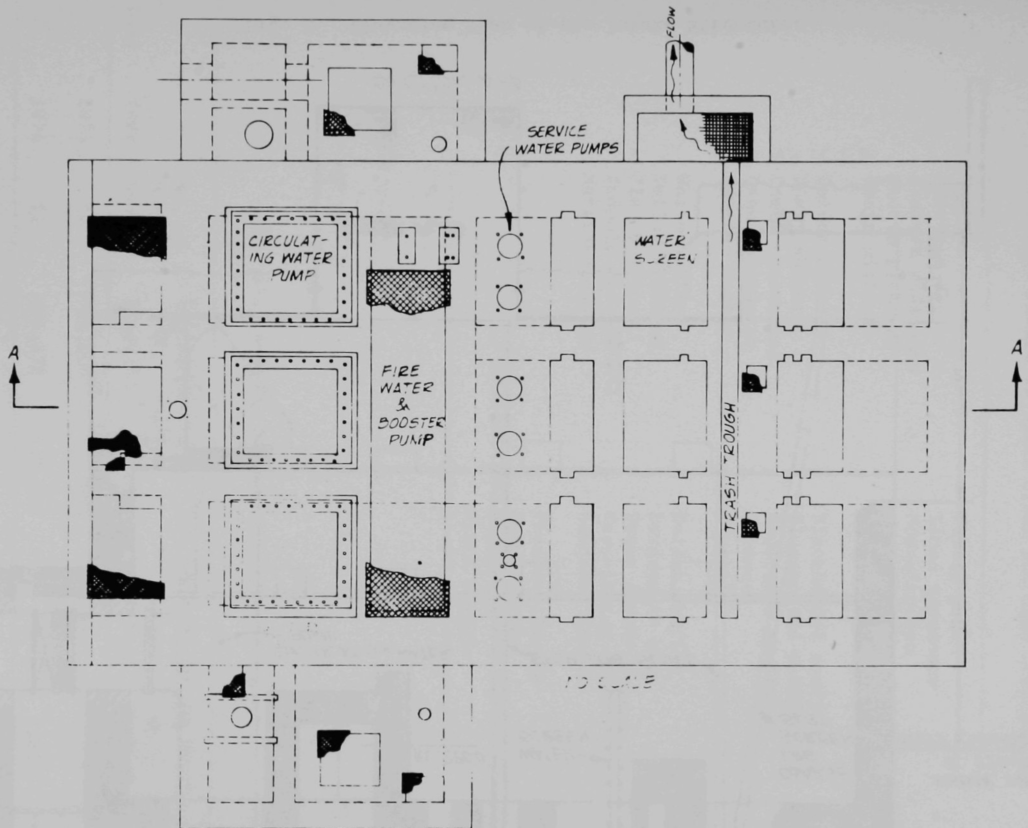


Fig. 2. Plan View of the Intake Structure.

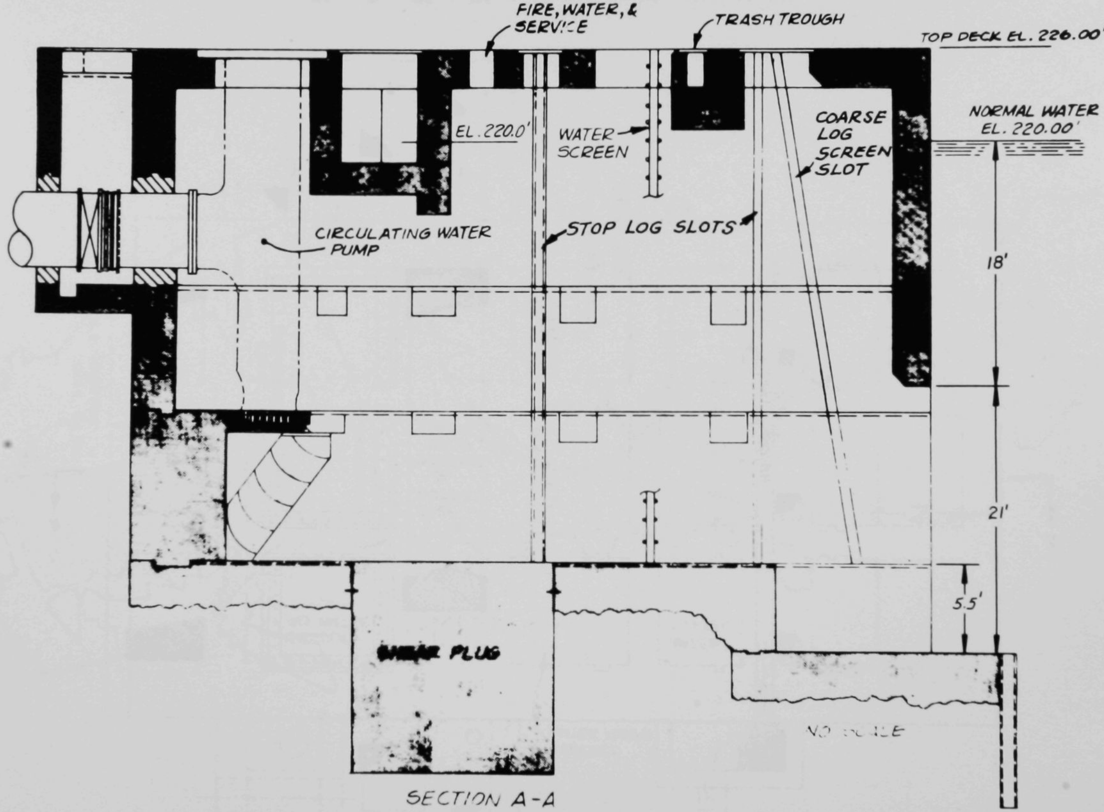


Fig. 3. Elevation View of the Intake Structure.

Table I. Fishes in Black Creek and Lake Robinson

Bowfin	Pirate perch
American eel	Lined topminnow
Eastern mudminnow	Mosquitofish
Redfin pickerel	Mud sunfish
Chain pickerel	Banded pigmy sunfish
Golden shiner	Blackbanded sunfish
Dusky shiner	Bluespotted sunfish
Creek chubsucker	Redbreast sunfish
Lake chubsucker	Warmouth
Spotted sucker	Bluegill
White catfish	Dollar sunfish
Yellow bullhead	Largemouth bass
Flat bullhead	Swamp darter
Tadpole madtom	Tessellated darter
Margined madtom	Sawcheek darter
	Piedmont darter
	Pumpkinseed
	Swampfish
	Black crappie

Table II. Summary of Fish Impingement Data

			Estimated No. of Fish Impinged during Months Sampled				
Unit	Year	No. of Months Sampled	Bluegill	Warmouth	Yellow Bullhead	White Catfish	Total
1	1974	11	11,005	660	1,550		12,241
2	1974	11	265,678	155,844		1,843	270,473

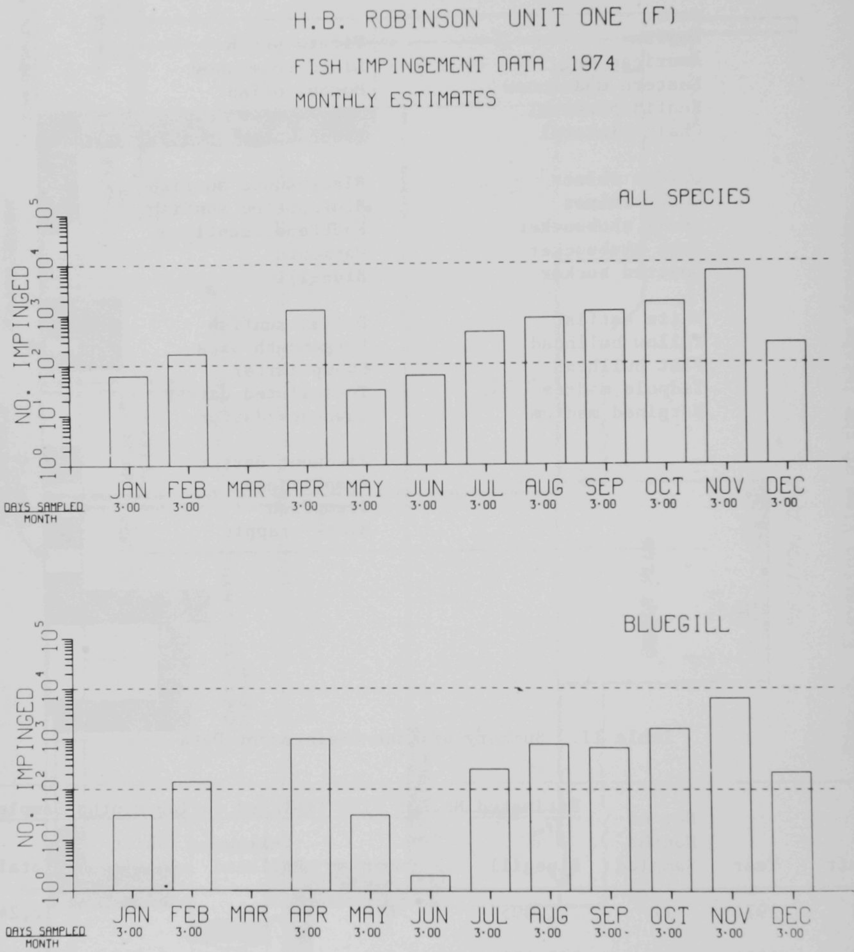


Fig. H1. Impingement Estimates.

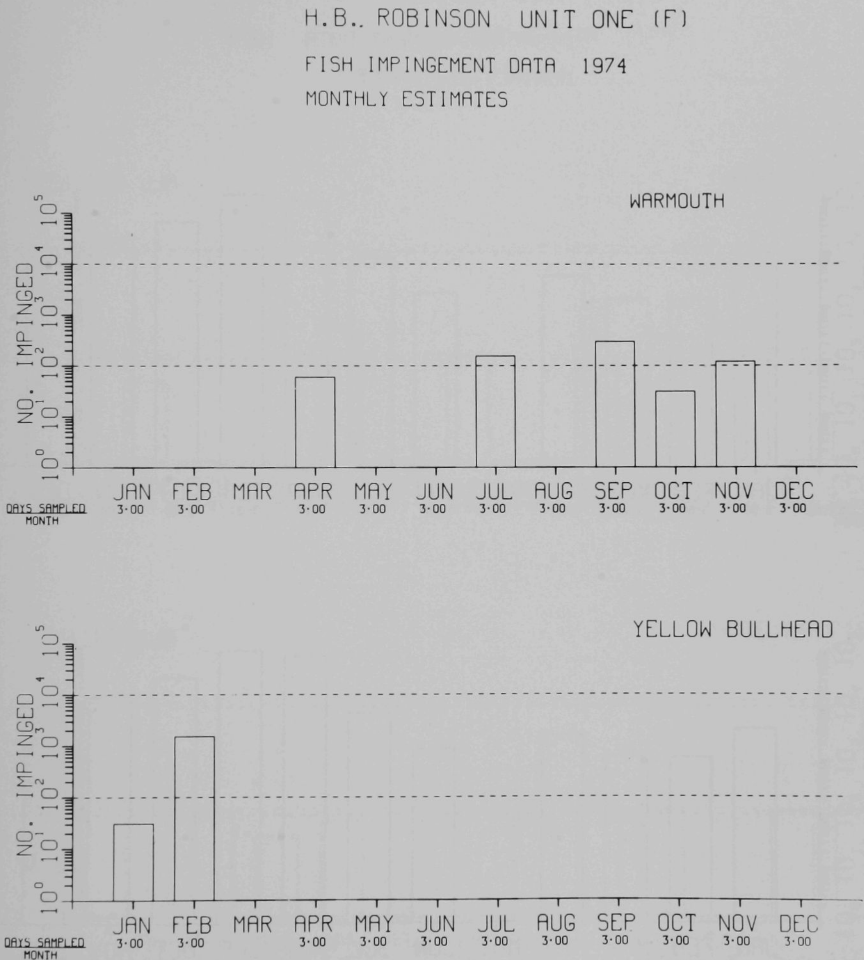


Fig. H2. Impingement Estimates.

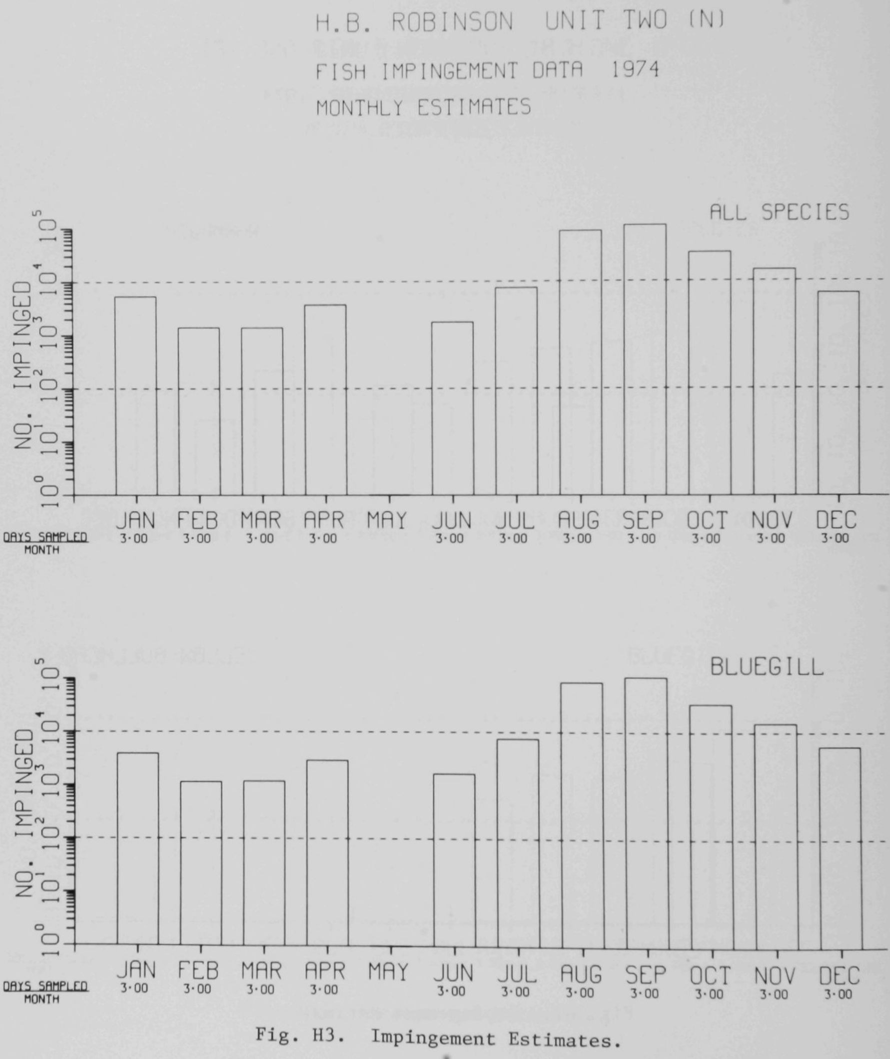
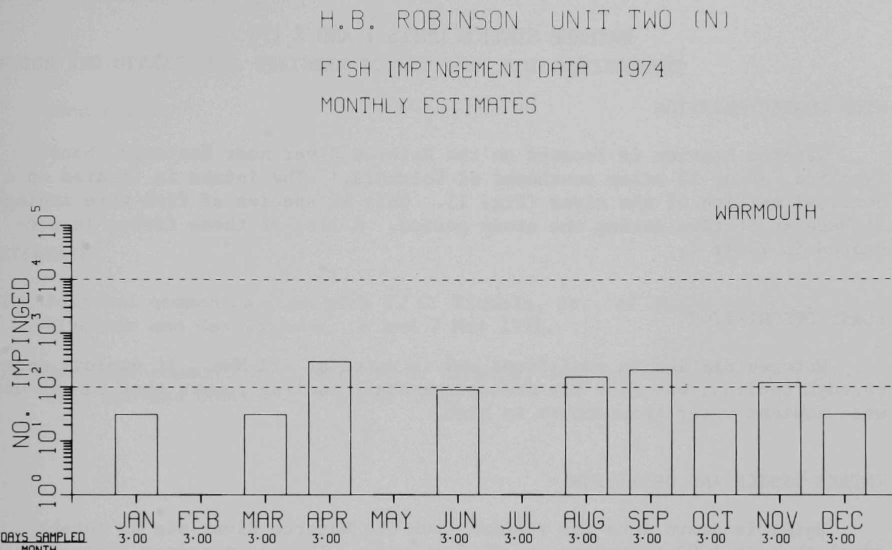


Fig. H3. Impingement Estimates.



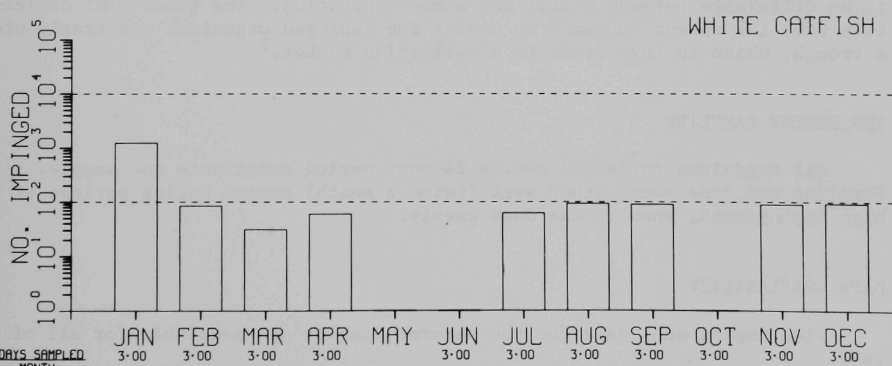


Fig. H4. Impingement Estimates.

WATEREE STATION UNITS 1 AND 2 (F)

SITE CHARACTERISTICS

Wateree Station is located on the Wateree River near Eastover, South Carolina, about 25 miles southeast of Columbia.[1] The intake is located on a nontidal portion of the river (Fig. 1). Only 16 species of fish were impinged at Wateree Station during the study period. A list of these fishes is presented in Table I.

PLANT DESCRIPTION

Wateree Station is coal fired and is rated at 772 MWe. It employs once-through cooling, but also has mechanical-draft cooling towers that can be used when ambient water temperature is high.

INTAKE DESIGN AND OPERATION

Water is drawn into the station from the Wateree River via an intake canal that is 1000 feet long and 50 feet wide. The water passes through trash racks and eight 3/8-inch mesh traveling screens. Four circulating-water pumps, each rated at 85,000 gpm (340,000 gpm total), supply water to the condensers (Figs. 2 and 3). The operation of the screens is automatic and there is no difference between winter and summer operation. The process of collection uses the screen backwash to sluice the impinged organisms and trash into a trough, which in turn leads to a collection basket.[2]

IMPINGMENT SAMPLING

All organisms collected over a 24-hour period constitute one sample. Sampling was done every other week (twice a month) except during periods of high impingement, when it was done weekly.

DATA AVAILABILITY

Fish impingement data for the Wateree Station are available for all of 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 and H2 are histograms representing the three most abundant species as well as all species impinged at the station. These totals are summarized in Table II.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCES

1. Personal communications with T. C. Nichols, Jr., of South Carolina Electric and Gas Company. 6 and 7 May 1976.

2. Personal communication with T. C. Nichols, Jr., of South Carolina Electric and Gas Company. 9 April 1976.

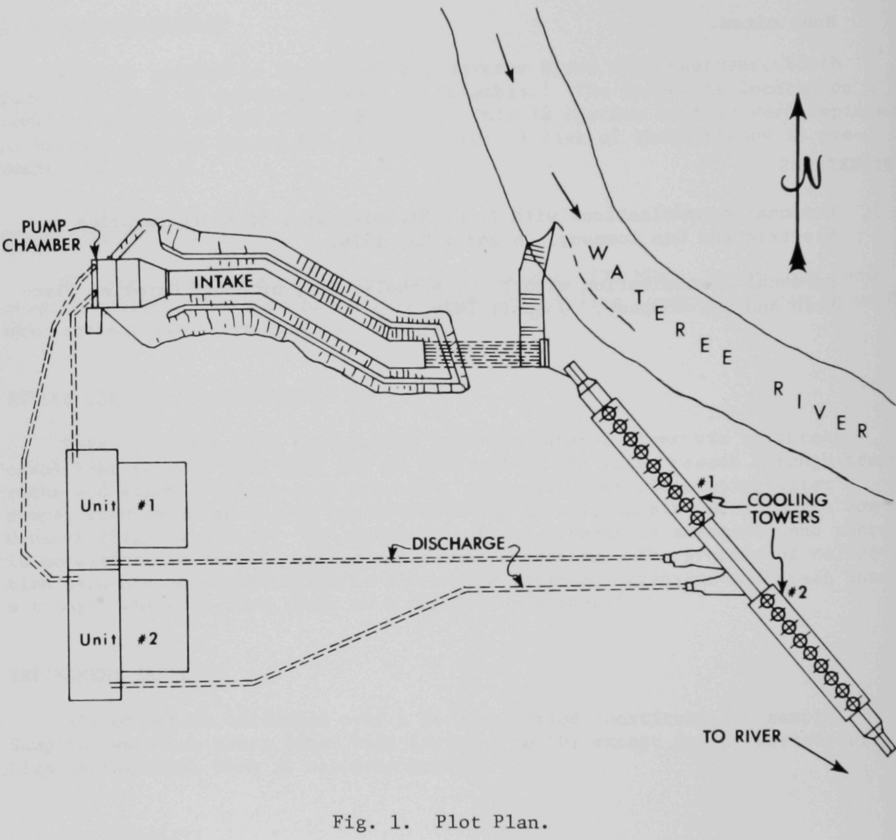


Fig. 1. Plot Plan.

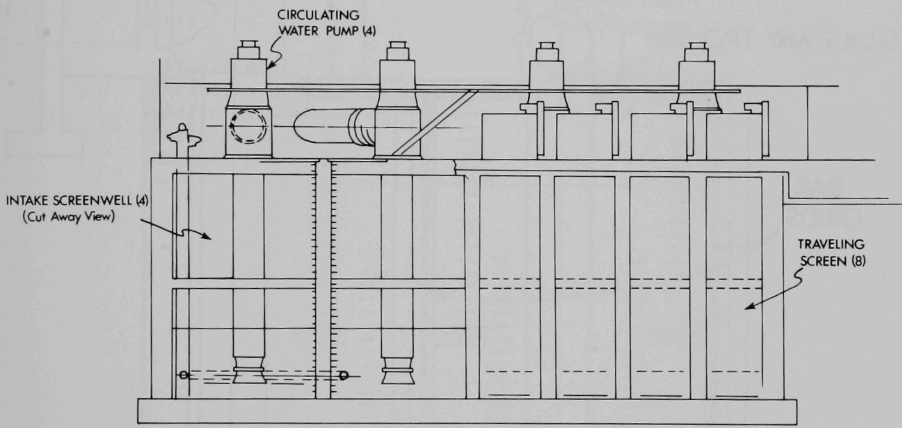


Fig. 2. Front View of the Intake Screenwell Structure.

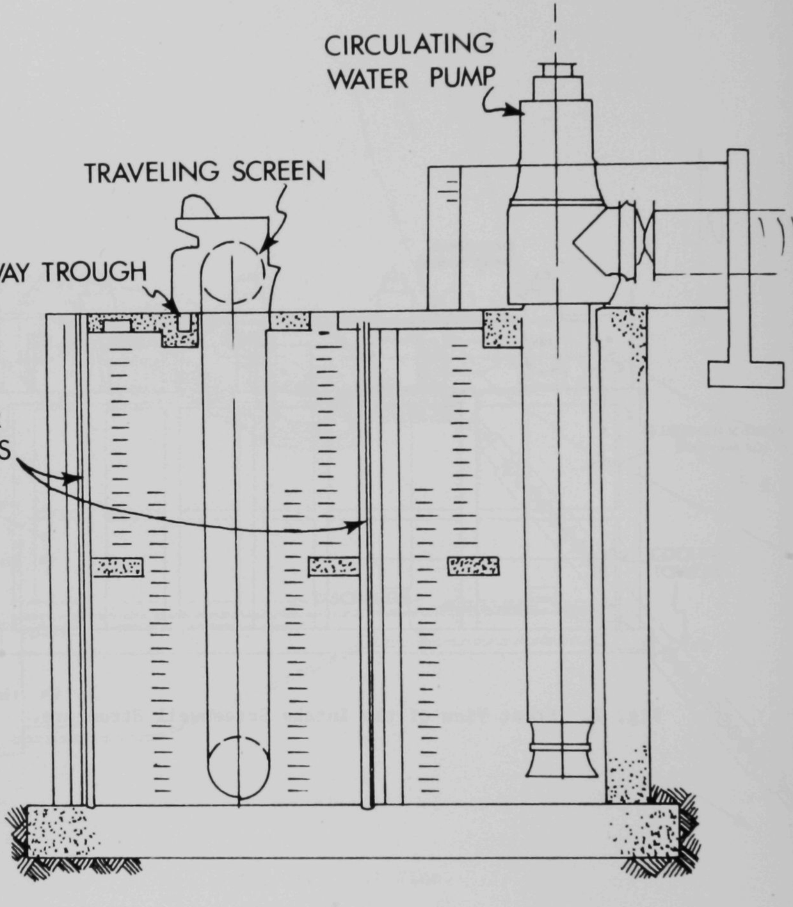


Fig. 3. Side View of the Intake Screenwell Structure.

Table I. Fishes Impinged at the Station in 1975

Alewife	Warmouth
Bowfin	Redear sunfish
Pirate perch	White bass
Flier	Striped bass
Carp	Yellow perch
Gizzard shad	White crappie
Threadfin shad	
Redfin pickerel	
White catfish	
Channel catfish	

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Threadfin Shad	Channel Catfish	Yellow Perch	Total
1975	12	3,054,197	928	903	3,058,814

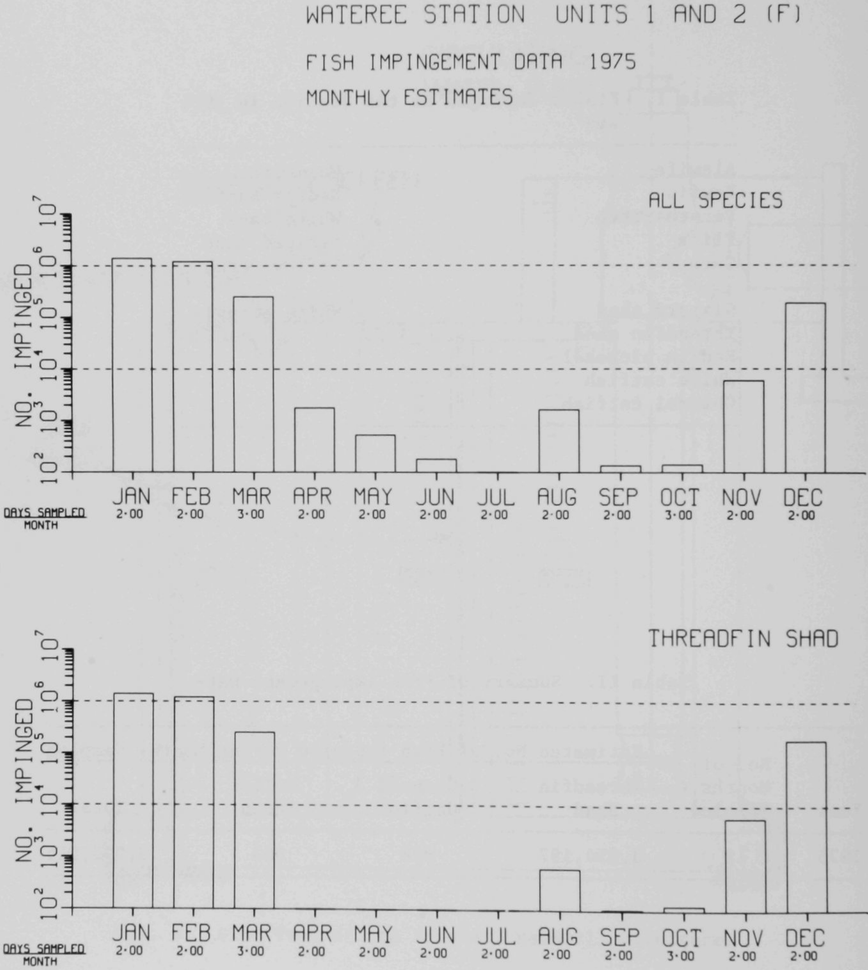


Fig. H1. Impingement Estimates.

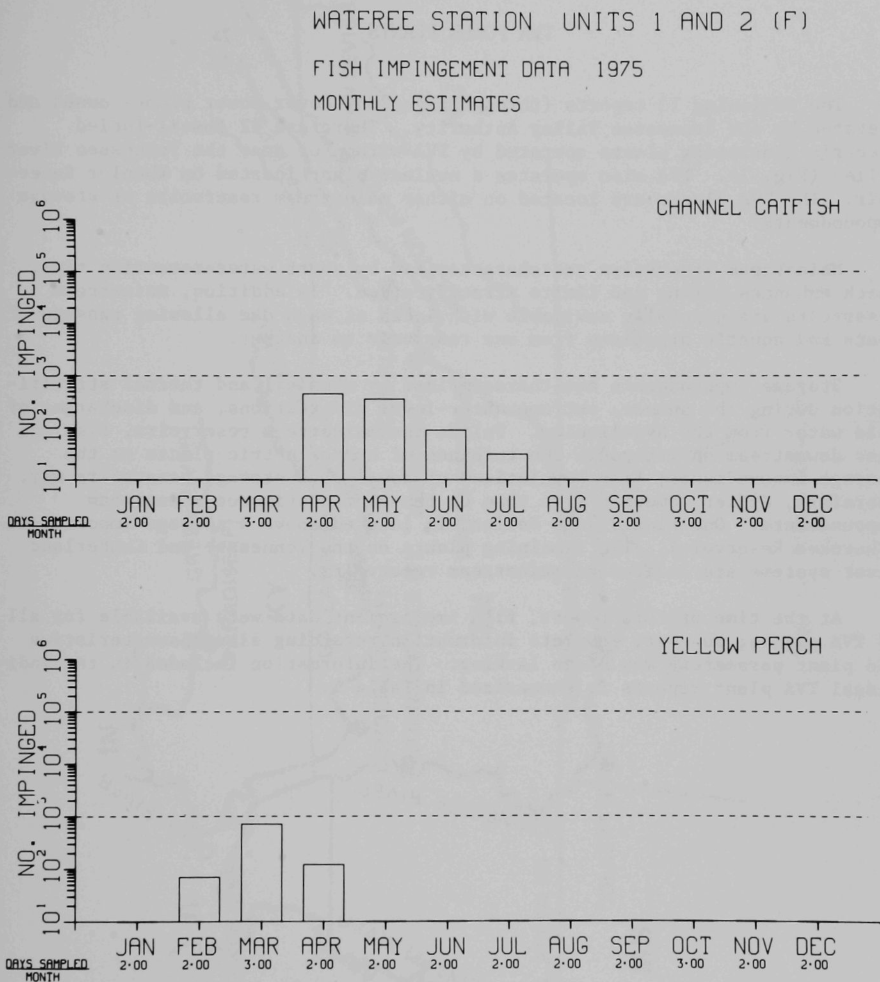


Fig. H2. Impingement Estimates.

TVA POWER PLANTS

The following 13 reports (through page 205) cover power plants owned and operated by the Tennessee Valley Authority. There are 12 fossil-fueled electric generating plants operated by TVA within or near the Tennessee River Valley (Fig. 1). TVA also operates a nuclear plant located on Wheeler Reservoir. The TVA plants are located on either mainstream reservoirs or storage impoundments.

Mainstream reservoirs are characterized by short water-retention time, which enhances mixing and limits stratification. In addition, mainstream reservoirs are generally navigable with locks at each dam allowing passage of boats and aquatic organisms from one reservoir to another.

Storage impoundments are characterized by chemical and thermal stratification during the summer, extreme water-level fluctuations, and discharges of cold water from the hypolimnion. Unlike the mainstream reservoirs, fish can pass downstream only through the turbines of hydroelectric plants at the storage impoundments; fish populations of contiguous storage reservoirs may, therefore, differ somewhat more than do those of contiguous mainstream impoundments. One plant, John Sevier, is located above a storage impoundment (Cherokee Reservoir). The remaining plants on the Tennessee and Cumberland River systems are located on mainstream reservoirs.

At the time of this report, fish impingement data were available for all 13 TVA plants; however, complete information regarding site characteristics and plant parameters was often lacking. The information included in the individual TVA plant reports is summarized in Table I.

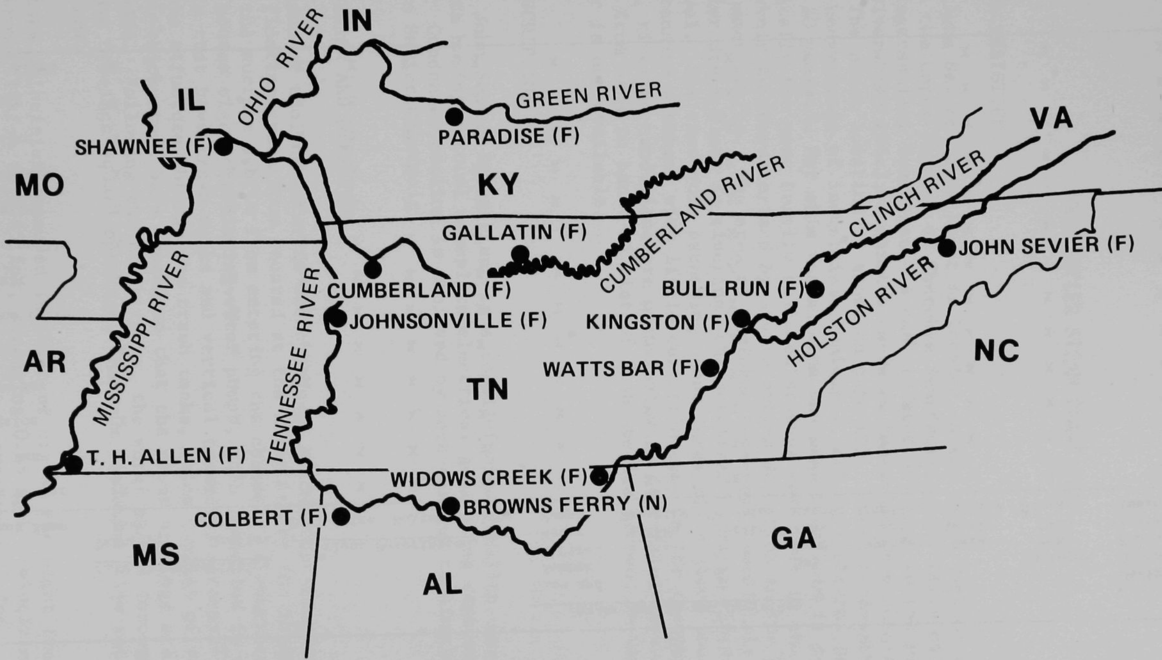


Fig. 1. Plant Locations.

Table I. Available Plant Information

Plant Name	Site Characteristics: Description	Site Characteristics: Species List	Plant Description: Fuel	Plant Description: Size	Plant Description: Units	Plant Description: Cooling	Intake Design and Operation: Size and Number of Circ. Water Pumps	Intake Design and Operation: Intake Velocity	Intake Design and Operation: Intake Location	Intake Design and Operation: Max. Cond. Flow Rate	Impingement Sampling	Data Availability	Impingement Data Summary	Design and Operational Features to Minimize Fish Impingement
John Sevier	X		X	X	X	X	X	X	X	X	X	X	X	X
Bull Run			X	X	X	X	X	X	X	X	X	X	X	X
Kingston	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Watts Bar	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Widows Creek	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Browns Ferry	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Colbert	X	X	X	X	X	X	X		X		X	X	X	X
Johnsonville	X	X	X	X	X	X			X	X	X	X	X	X
Gallatin	X	X	X	X	X	X	X		X	X	X	X	X	X
Cumberland	X	X	X	X	X	X	X		X	X	X	X	X	X
Paradise	X		X	X	X	X	X		X	X	X	X	X	X
Shawnee	X		X	X	X	X		X	X	X	X	X	X	X
T. H. Allen	X		X	X	X	X	X		X	X	X	X	X	X

JOHN SEVIER STEAM PLANT (F)

SITE CHARACTERISTICS

The John Sevier Steam Plant is located on the south bank of the Holston River, at the upper reaches of Cherokee Reservoir, about three miles southeast of Rogersville, Tennessee. A dam, located adjacent to the plant site at Holston River Mile 106.3, separates Cherokee Reservoir from John Sevier Reservoir. The plant location is shown on page 105. Cherokee Reservoir has received heavy loads of industrial, municipal, and agricultural pollution for the past 30 years.[1] For this reason, the Cherokee Reservoir is considered to be organically the most heavily polluted storage reservoir in the TVA system. The reservoir is characterized by severe oxygen depletion in the hypolimnion during summer months. The area of Cherokee Reservoir immediately below the John Sevier Steam Plant is riverine, characterized by large fluctuations in water level. The reservoir extending about three miles above the plant contains extensive overbank with little current except in the channel. Farther upstream, riverine conditions are prevalent with flow fairly evenly distributed from bank to bank. A list of fish species present in Cherokee Reservoir is not available.

PLANT DESCRIPTION

The John Sevier Steam Plant is a fossil-fueled facility consisting of four units having a total nameplate electrical generating capacity of about 847 MWe. Condenser cooling is achieved by once-through cooling with water from John Sevier Reservoir.

INTAKE DESIGN AND OPERATION

Condenser cooling water is drawn through a 1004-foot-long intake channel. A floating trash boom located at the river end of the intake prevents much of the surface debris from entering the channel. A concrete pumping station houses eight circulating-water pumps, each installed in separate suction pits that have trash racks and vertical traveling screens.[2] Water enters the intake structure through the trash racks, which consist of vertical 0.62-inch-thick steel bars spaced so that the clear openings are about 3.5 inches wide. Following the trash racks, the water passes through the screens, which have 3/8-inch-square openings. Maximum condenser flow rate is 454,586 gpm.

Intake velocities measured in front of six of the eight trash racks ranged from 0.18 fps to 0.65 fps, averaging 0.45 fps. Velocities measured at two points in the intake channel ranged from zero to 0.85 fps. The velocity was greatest near the center of the water column immediately downstream of the trash boom.

IMPINGEMENT SAMPLING

Weekly samples were collected between August 1974 and March 1975. At the beginning of a sample period, all traveling screens were rotated and washed clean of fish and debris. Twenty-four hours later, the screens were again rotated and washed. The impinged fish were collected and grouped by species into length categories of integral multiples of 25 mm. Only those screens that had water passing through them at the end of the period were sampled.

DATA AVAILABILITY

Fish impingement data for the John Sevier Plant are available for August 1974 through March 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing the total numbers of the three most abundant species as well as all species impinged at the John Sevier Steam Plant. These totals are summarized in Table I.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCES

1. "Proposed Studies to Determine Effects of John Sevier Steam Plant Operations on the Fish Populations of Cherokee Reservoir." Tennessee Valley Authority. 4 December 1974.

2. "Impingement at John Sevier Steam Plant." Tennessee Valley Authority. (Undated.)

Table I. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Gizzard Shad	Threadfin Shad	Channel Catfish	Total
1974	5	12,338	4,613	540	18,299
1975	3	101,412	30,874	300	132,900

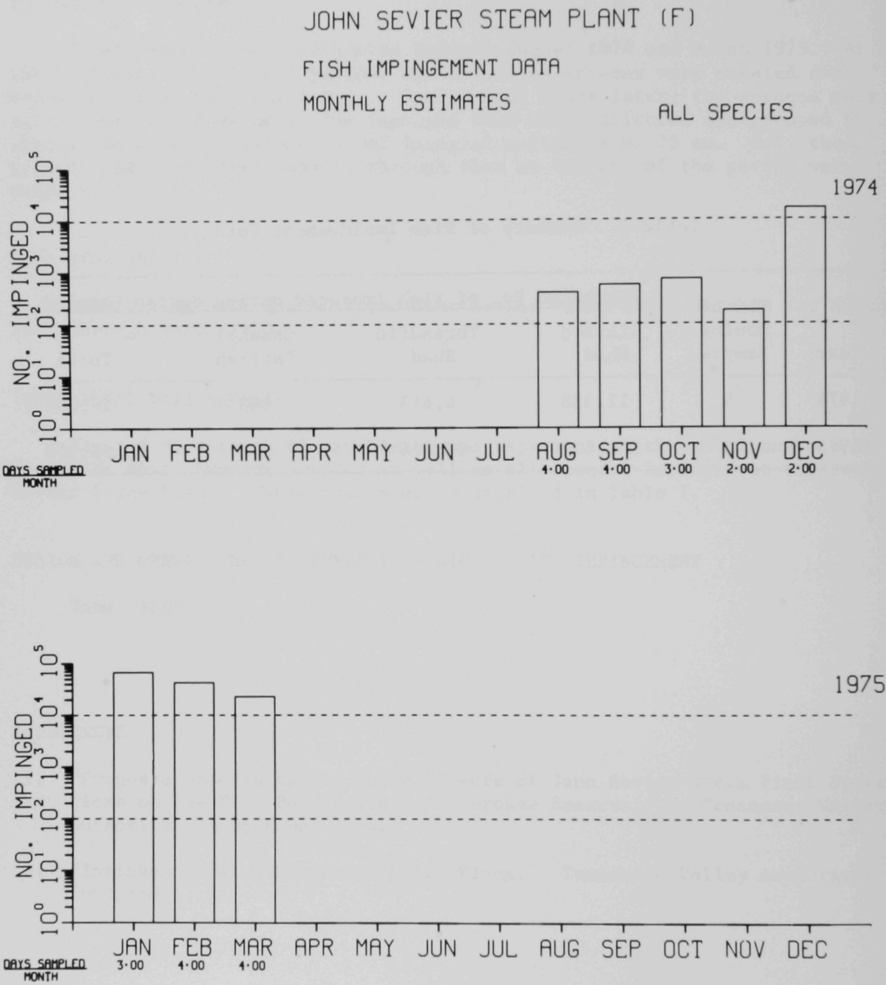


Fig. H1. Impingement Estimates.

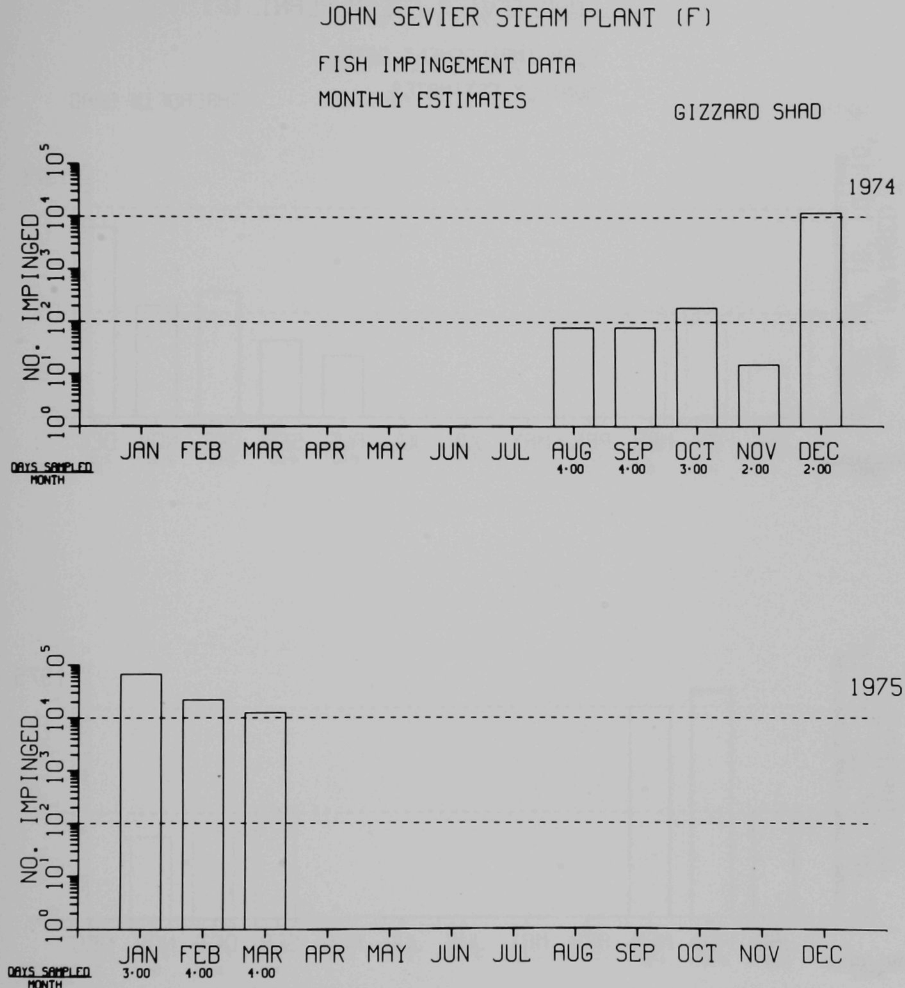


Fig. H2. Impingement Estimates.

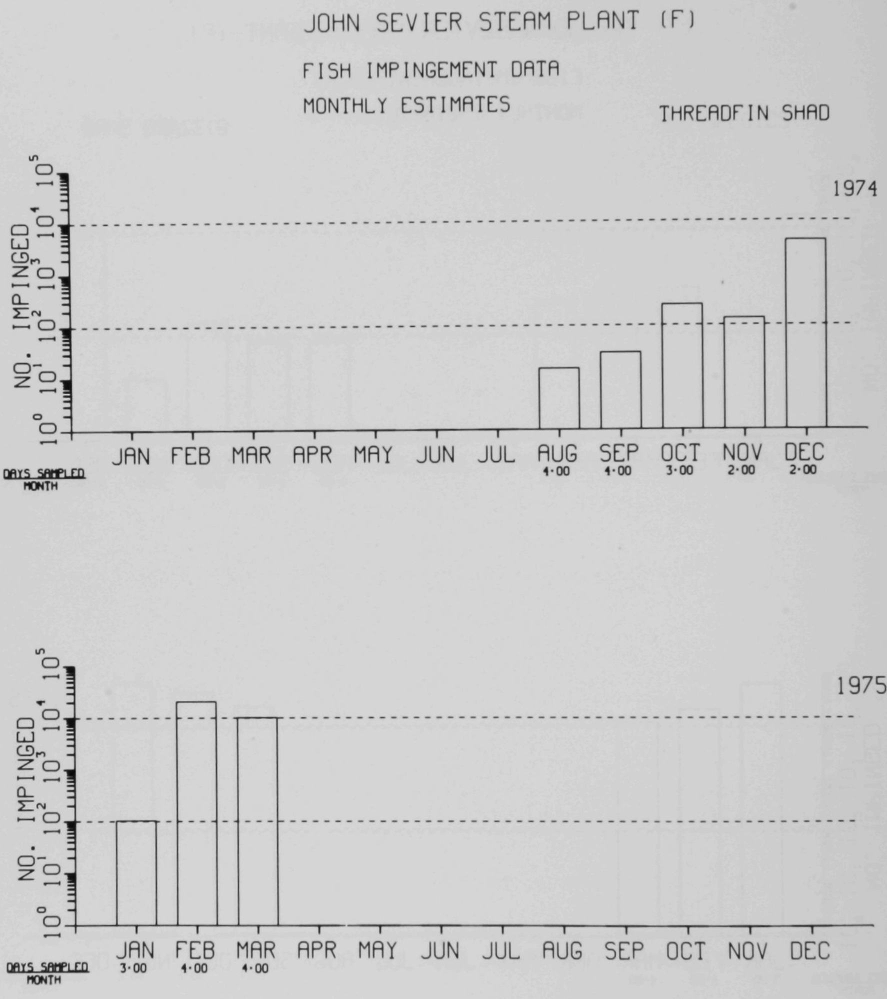


Fig. H3. Impingement Estimates.

JOHN SEVIER STEAM PLANT (F)

FISH IMPINGEMENT DATA

MONTHLY ESTIMATES

CHANNEL CATFISH

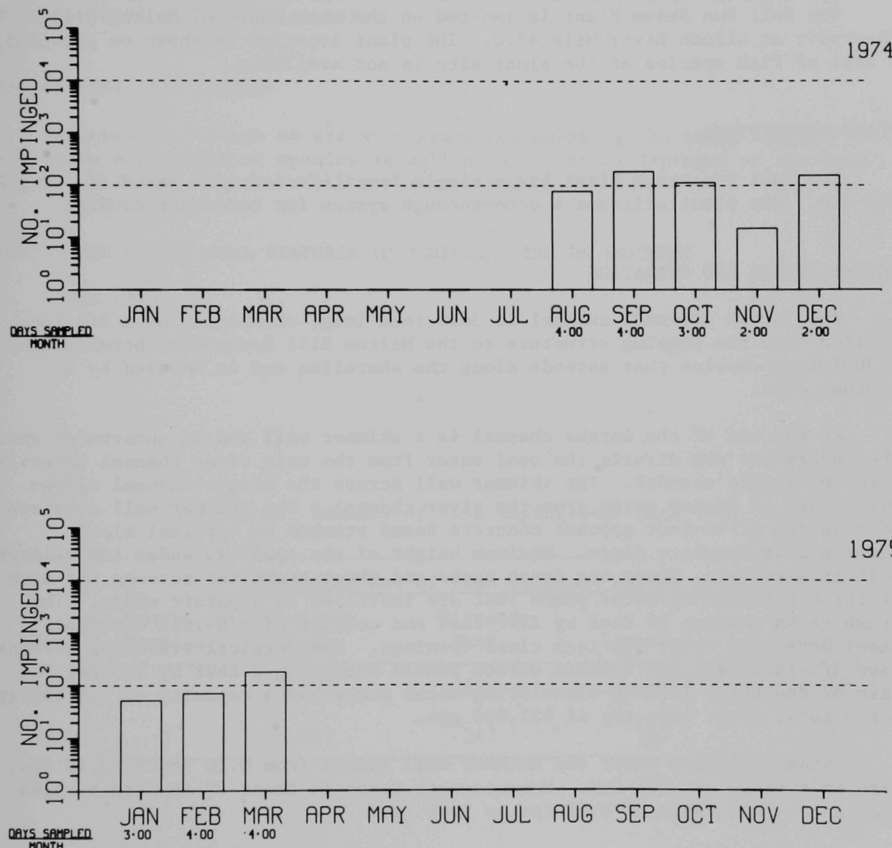


Fig. H4. Impingement Estimates.

BULL RUN STEAM PLANT (F)

SITE CHARACTERISTICS

The Bull Run Steam Plant is located on the east shore of Melton Hill Reservoir at Clinch River Mile 48.0. The plant location is shown on page 105. A list of fish species at the plant site is not available.

PLANT DESCRIPTION

The Bull Run Steam Plant has a single fossil-fueled unit rated at 950 MWe. The plant utilizes a once-through system for condenser cooling.

INTAKE DESIGN AND OPERATION

The intake approach channel is 3680 feet long, consisting of a 679-foot section from the pumping structure to the Melton Hill Reservoir shoreline and a 3001-foot section that extends along the shoreline and is bounded by an earthen dike.

At the end of the intake channel is a skimmer wall and an underwater dam. The underwater dam diverts the cool water from the main river channel directly into the intake channel. The skimmer wall across the intake channel allows withdrawal of deeper water from the river channel. The skimmer wall consists of a series of 40-foot precast concrete beams stacked in vertical slots between cast-in-place piers. Maximum height of the openings under the skimmer wall is six feet. There are trash racks and three traveling screens for each of three circulating-water pumps that are installed in separate wells. The trash racks measure 24 feet by 12.7 feet and consist of 5/8-inch vertical steel bars with about 3.5-inch clear openings. The vertical traveling screens have 3/8-inch mesh and contain screen panels measuring 2 feet by 10 feet. Each of the three 1000-hp circulating-water pumps has a capacity of 139,000 gpm for a total plant capacity of 417,000 gpm.

Intake velocity under the skimmer wall ranges from 0.10 fps to 0.40 fps, with an average of 0.24 fps. Measurements taken in front of the trash racks show an overall range of 0.65 fps to 1.80 fps.

Velocity profiles across the intake channel were made at two locations. About 321 feet upstream of the pumping structure velocities ranged from 0.30 fps to 1.00 fps. Farther upstream in the channel, velocities ranged from zero to 0.70 fps. Velocity was not measurable throughout most of the left side of the channel.

IMPINGEMENT SAMPLING

All vertical traveling screens were rotated and washed clean of fish and debris once each week. Twenty-four hours later the screens were again rotated and washed. Impinged fish were collected and separated by species into length categories of integral multiples of 25 mm.

DATA AVAILABILITY

Fish impingement data for the Bull Run Steam Plant are available for 7 August 1974 through March 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing the total numbers of the three most abundant species as well as all species impinged at the Bull Run Steam Plant. These totals are summarized in Table I.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

Table I. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Threadfin Shad	Gizzard Shad	Logperch	Total
1974	5	13,595	251	461	14,696
1975	3	6,377	542	151	7,212

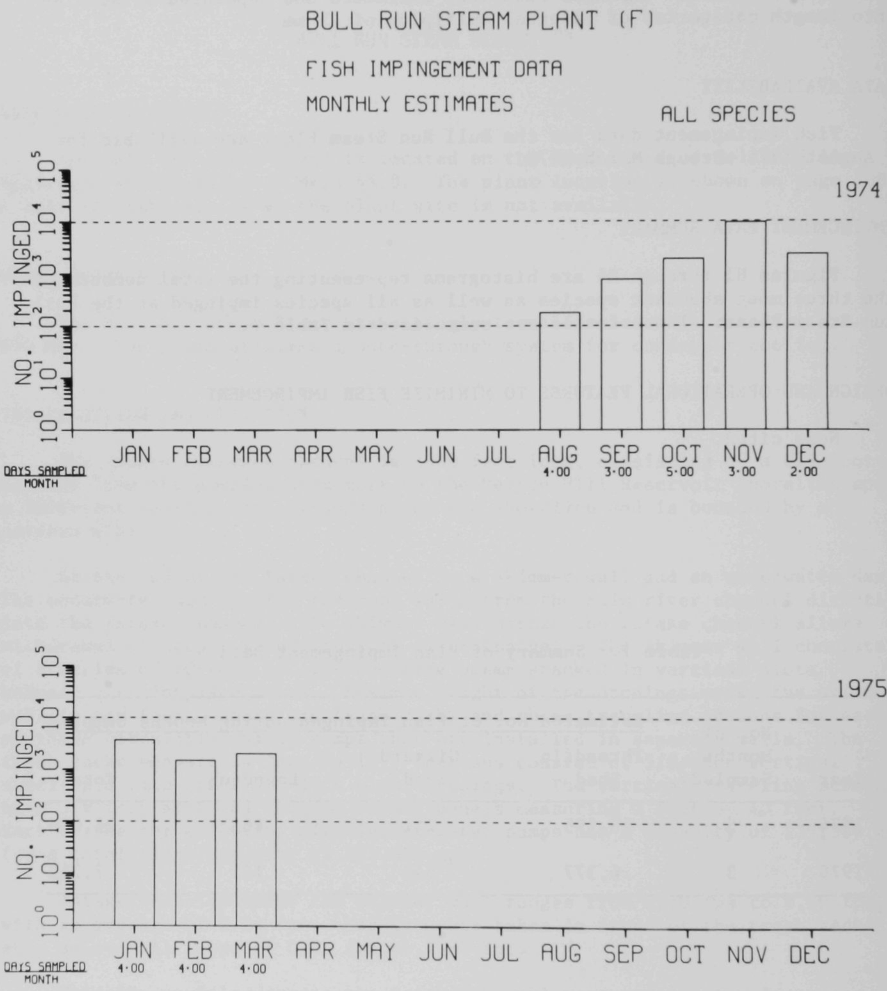


Fig. H1. Impingement Estimates.

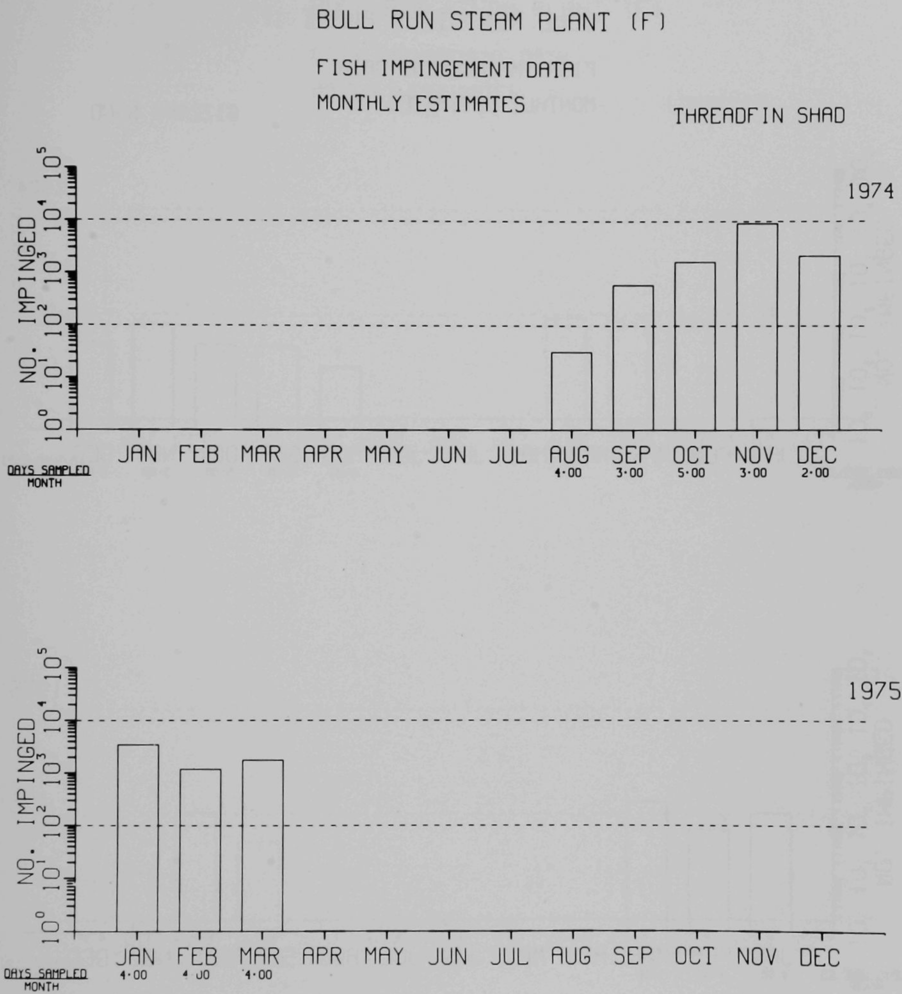
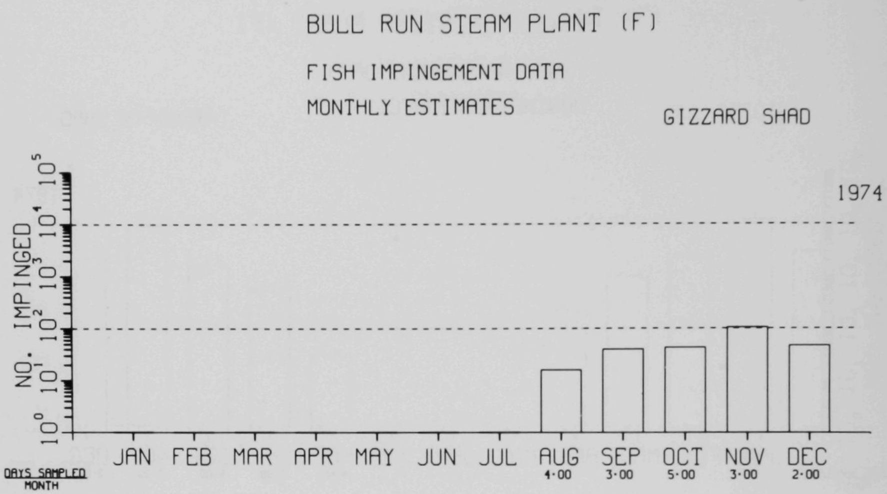


Fig. H2. Impingement Estimates.



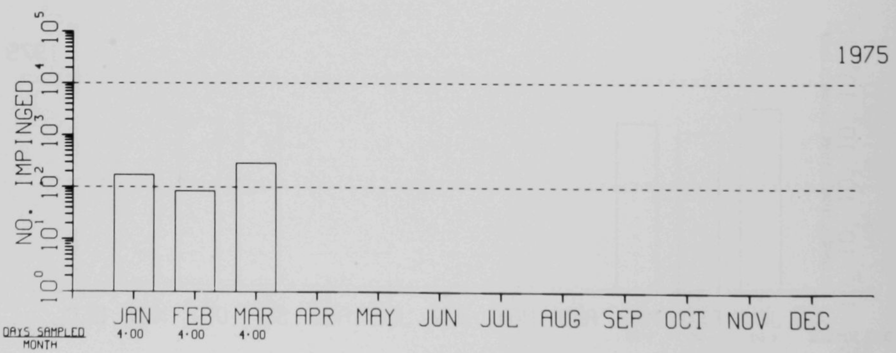


Fig. H3. Impingement Estimates.

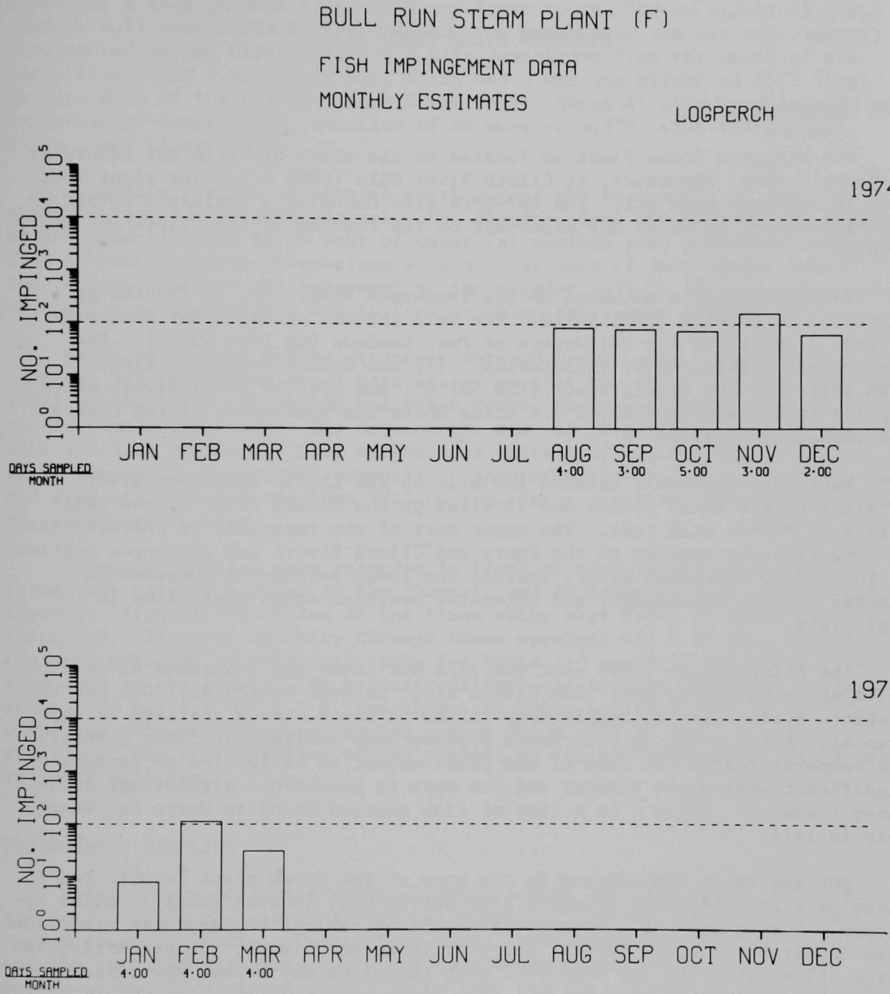


Fig. H4. Impingement Estimates.

KINGSTON STEAM PLANT (F)

SITE CHARACTERISTICS

The Kingston Steam Plant is located on the shore of Watts Bar Reservoir in Roane County, Tennessee, at Clinch River Mile (CRM) 2.7. The plant location is shown on page 105. The 697-acre site occupies a peninsula formed by the impoundment of Watts Bar Reservoir on the courses of the Clinch and Emory Rivers.

Watts Bar Dam is situated on the Tennessee River. It is located at Tennessee River Mile (TRM) 529.9. The main channel of Watts Bar Reservoir extends 72 miles to the tailwaters of Fort Loudoun Dam (TRM 602.3). The reservoir has three major tributaries: (1) the Little Tennessee River (TRM 601); (2) the Clinch River (TRM 567.8); and (3) the Emory River, which empties into the Clinch River 4.4 miles above the confluence of the Clinch and Tennessee Rivers.[1]

Watts Bar Reservoir extends 1.0 mile up the Little Tennessee River, 12 miles up the Emory River, and 23 miles up the Clinch River to the tailwaters of Melton Hill Lake. The upper part of the reservoir is characterized by long riverine reaches on the Emory and Clinch Rivers and the upper portion of the Little Tennessee River, whereas the lower portion is composed of flooded creeks, embayments, and extensive overbank areas where flow is negligible.

The Clinch River flows past the site and joins the Tennessee River 37.7 miles above Watts Bar Dam. The Clinch River between Melton Hill Dam and the Kingston Steam Plant is fairly deep (25 to 32 feet) and is confined to the channel. A few coves in this reach provide some habitat for fish; however, the temperatures in the area of the plant appear to be too low to support a significant warm-water fishery and too warm to maintain a significant cold-water fishery.[1] Table I is a list of fish species found in Watts Bar Reservoir in 1974.

Ambient water temperature in the area of the steam plant is affected in large part by cold-water releases from Norris Dam, located about 75 miles upstream. During most of the year, Clinch River ambient temperatures are colder than temperatures in either the Emory or Tennessee Rivers. Consequently, the water column in Watts Bar Reservoir near the plant may become stratified.

PLANT DESCRIPTION

The Kingston Steam Plant is a fossil-fueled station consisting of nine units, which have a total generating capacity of 1700 MWe. The condensers are cooled with once-through cooling water withdrawn from the Emory River.

INTAKE DESIGN AND OPERATION

The possibility of stratification, along with high summer temperatures in a swan-pond embayment located at the mouth of the intake channel, made necessary a deep channel from the Emory River to the intake structure and a skimmer wall across the intake channel. An underwater dam was subsequently constructed on the Clinch River 0.5 mile downstream from the mouth of the Emory River (CRM 3.9). This dam, which has a maximum height of 20.5 feet, retains much of the colder Clinch River water, theoretically resulting in an intake-water-temperature reduction of as much as 4.5°F below the ambient Emory River temperature.

A pumping station is located northeast of the powerhouse at the head of the 4500-foot-long intake channel. The 413-foot-long skimmer wall is located at the channel inlet in 35 feet of water (at minimum pool elevation) and has five 15-foot-high bottom openings with a total area of 3600 square feet.[2] The maximum depth of the embayment at the skimmer wall is 40 feet. The skimmer wall prevents surface debris from entering the intake channel.

Water enters the intake structure through trash racks, which consist of vertical 5/8-inch-thick steel bars spaced so that the clear openings are 3-5/8 inches wide. Following the trash racks, the water passes through vertical traveling screens. The screens are made of 12-gauge galvanized wire with 3/8-inch openings. Each of the nine units utilizes two circulating-water pumps with individual pumpwells. Each of Units 1-4 requires 90,000 gpm and each of Units 5-9 requires 121,400 gpm, for a plant total of 967,000 gpm of cooling-water flow.

Velocity profiles were recorded in front of each intake trash rack, across the narrowest point of the channel, and in front of each skimmer-wall opening. Highest velocities at the trash racks were found in front of Units 5-9. The mean velocity through these openings was 0.55 fps, whereas the mean velocity at the trash racks for Units 1-3 was 0.29 fps (Unit 4 was shut down at the time). The velocity differences are due primarily to larger pumps (450 hp) for Units 5-9 than those for Units 1-4 (350 hp). Velocities under the skimmer-wall openings had a mean value of 0.56 fps. A velocity profile at the cross section of the channel at its narrowest point had a mean value of 0.74 fps.

IMPINGEMENT SAMPLING

Samples were collected weekly between August 1974 and March 1975. At the beginning of the sample period all traveling screens were rotated and washed clear of debris. Twenty-four hours later, screens were washed again, and the impinged fish were collected in a catch basket installed in the screen-washwater sluiceway. For Units 1-8, the two screens of each unit were washed simultaneously and fish counts totaled for each. For Unit 9, the two screens were usually washed separately because preliminary data indicated that this set of screens yielded about half the total number of fish collected from all screens.

Samples only from those screens that had water passing through them during the sample period were counted. If a pump operated at the end of the sample but only during a portion of the 24-hour sample, the sample was counted. If the pump operated during a portion of the 24-hour sample and was turned off prior to the time the count was made, the screen sample was discarded.

DATA AVAILABILITY

Data on fish impingement at the Kingston Steam Plant are available for 7 August 1974 through March 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing extrapolated totals of the three most abundant species as well as all species impinged at the Kingston Steam Plant. These totals are summarized in Table II.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCES

1. "Effects of Kingston Steam Plant on the Fish Population of Watts Bar Reservoir." Tennessee Valley Authority - Division of Forestry, Fisheries, and Wildlife Development. 6 December 1974.

2. Impingement at Kingston Steam Plant. Tennessee Valley Authority. (Undated.)

Table I. Fish Species Found in Watts Bar Reservoir in 1974

Skipjack herring	Bluegill
Rock bass	Redear sunfish
Freshwater drum	Smallmouth bass
River carpsucker	Spotted bass
White sucker	Largemouth bass
Banded sculpin	Spotted sucker
Carp	White bass
Gizzard shad	Yellow bass
Threadfin shad	Striped bass
Mosquitofish	River redhorse
Mooneye	Black redhorse
Northern hog sucker	Golden redhorse
Chestnut lamprey	Shorthead redhorse
Blue catfish	Emerald shiner
Yellow bullhead	Spotfin shiner
Channel catfish	Steelcolor shiner
Smallmouth buffalo	Logperch
Bigmouth buffalo	Bluntnose minnow
Black buffalo	Bullhead minnow
Brook silverside	Paddlefish
Spotted gar	White crappie
Longnose gar	Black crappie
Shortnose gar	Flathead catfish
Redbreast sunfish	Sauger
Warmouth	Walleye

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Threadfin Shad	Bluegill	Freshwater Drum	Total
1974	5	404,847	971	3,132	412,510
1975	3	18,764	1,398	2,182	30,257

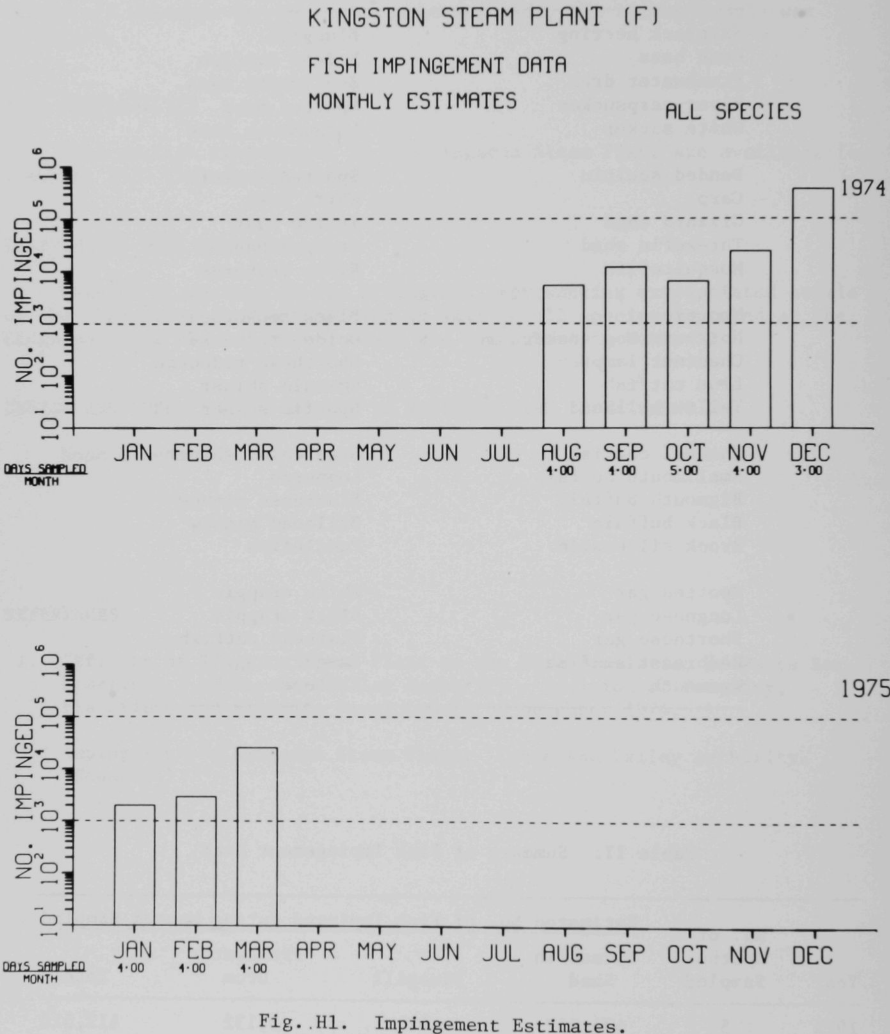


Fig. H1. Impingement Estimates.

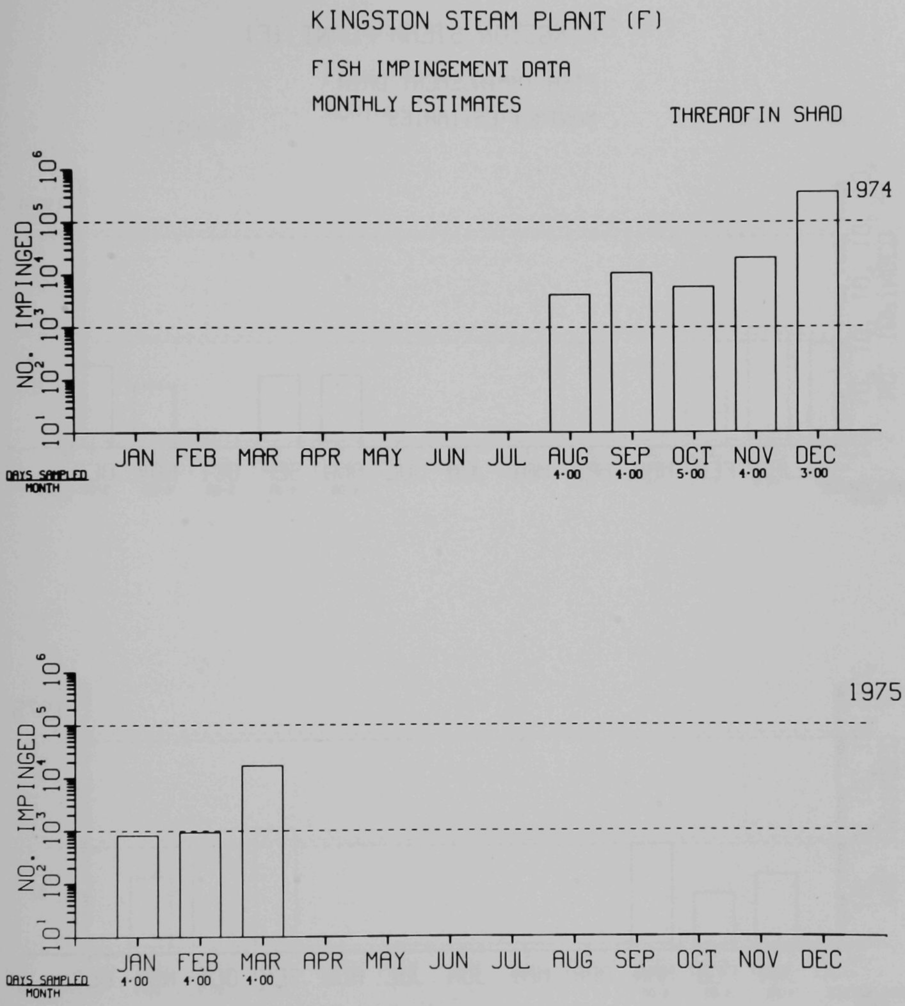


Fig. H2. Impingement Estimates.

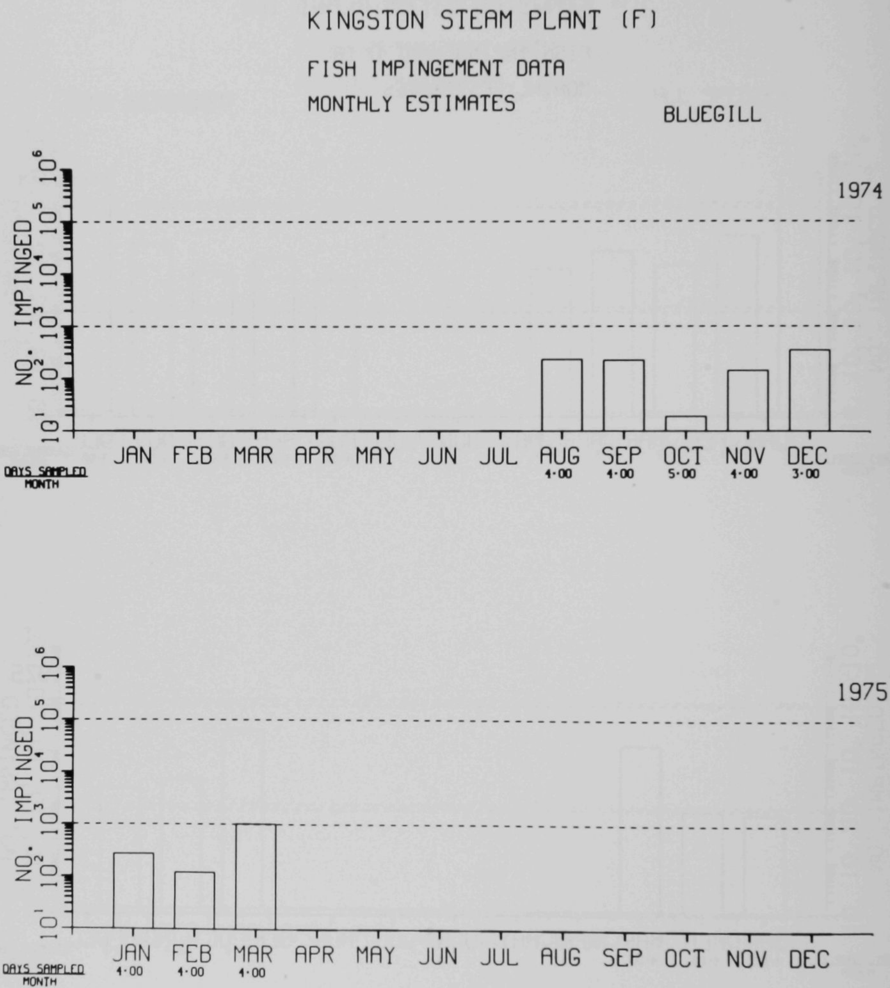


Fig. H3. Impingement Estimates.

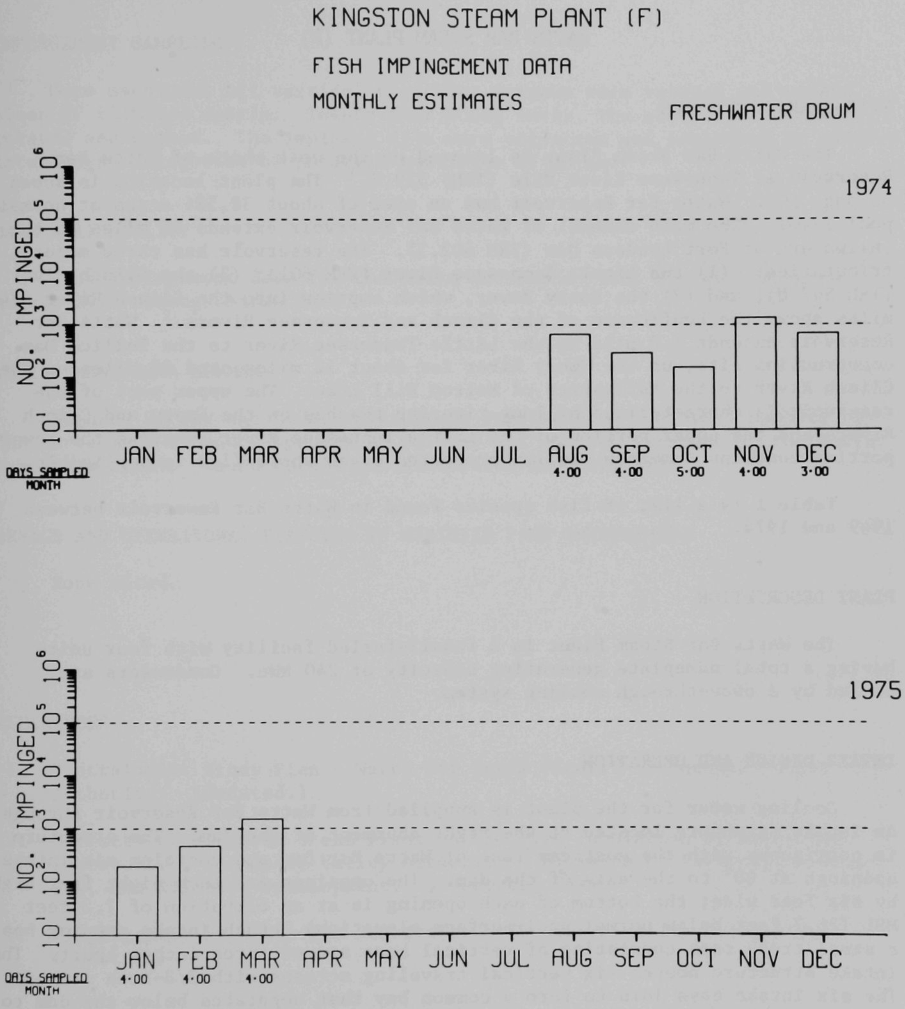


Fig. H4. Impingement Estimates.

WATTS BAR STEAM PLANT (F)

SITE CHARACTERISTICS

The Watts Bar Steam Plant is located on the west shore of Watts Bar Reservoir at Tennessee River Mile (TRM) 529.2.[1] The plant location is shown on page 105. Watts Bar Reservoir has an area of about 38,584 acres at normal pool level. The main channel of Watts Bar Reservoir extends 72 miles to the tailwaters of Fort Loudoun Dam (TRM 602.3). The reservoir has three major tributaries: (1) the Little Tennessee River (TRM 601); (2) the Clinch River (TRM 567.8); and (3) the Emory River, which empties into the Clinch River 4.4 miles above the confluence of the Clinch and Tennessee Rivers.[2] Watts Bar Reservoir extends 1.0 mile up the Little Tennessee River to the Tellico Dam construction site, up the Emory River for about 12 miles, and 23 miles up the Clinch River to the tailwaters of Melton Hill Lake. The upper part of the reservoir is characterized by long riverine reaches on the Emory and Clinch Rivers and the upper portion of the Little Tennessee River, whereas the lower portion contains numerous shallow protected coves where flow is negligible.

Table I is a list of fish species found in Watts Bar Reservoir between 1949 and 1974.

PLANT DESCRIPTION

The Watts Bar Steam Plant is a fossil-fueled facility with four units having a total nameplate generating capacity of 240 MWe. Condensers are cooled by a once-through cooling system.

INTAKE DESIGN AND OPERATION

Cooling water for the plant is supplied from Watts Bar Reservoir through an intake structure located at the right abutment of the dam. The structure is contiguous with the upstream face of Watts Bar Dam and contains six intake openings at 90° to the axis of the dam. The openings are each eight feet high by six feet wide; the bottom of each opening is at an elevation of 7.2 feet MSL (28.7 feet below normal pool-surface elevation). Each intake opening has a steel trash rack consisting of vertical bars spaced three inches apart. The intake structure houses six vertical traveling screens with 3/8-inch mesh. The six intake bays join to form a common bay that separates below the dam to form two leads to the powerhouse.

Circulating water for the condensers is supplied by gravity from the Watts Bar Reservoir through a conduit system that is about 3400 feet long. The circulating-water system is designed to produce a maximum total flow of

280,071 gpm when the reservoir level is at 733 feet MSL and the tailwater at the steam-plant discharge is at an elevation of 699 feet MSL. With this flow through the six screens, the calculated velocity through the trash racks is 0.84 fps.[3]

IMPINGEMENT SAMPLING

Once each week all vertical traveling screens were rotated and washed clean of fish and debris. Twenty-four hours later, the screens were again rotated and washed. The impinged fish were collected and separated by species into length categories of integral multiples of 25 mm.

DATA AVAILABILITY

Fish impingement data for the Watts Bar Steam Plant are available for August 1974 through March 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing the total numbers of the three most abundant species as well as all species impinged at the Watts Bar Steam Plant. These totals are summarized in Table II.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCES

1. "Entrainment Study Plan - Watts Bar Steam Plant." Tennessee Valley Authority. (Undated.)

2. "Effects of Kingston Steam Plant on the Fish Population of Watts Bar Reservoir." Tennessee Valley Authority - Division of Forestry, Fisheries, and Wildlife Development. 6 December 1974.

3. "Impingement at Watts Bar Reservoir." Tennessee Valley Authority. (Undated.)

Table I. Fish Species Collected in the Reservoir from 1949 to 1974

Paddlefish	Channel catfish
Spotted gar	Tadpole madtom
Longnose gar	Flathead catfish
Shortnose gar	Mosquitofish
Skipjack herring	Brook silverside
Gizzard shad	White bass
Threadfin shad	Yellow bass
Mooneye	Striped bass
Carp	Rock bass
Golden shiner	Bluegill
Emerald shiner	Redbreast sunfish
Spotfin shiner	Warmouth
Whitetail shiner	Orangespotted sunfish
Steelcolor shiner	Longear sunfish
Bluntnose minnow	Redear sunfish
Fathead minnow	Smallmouth bass
Silver chub	Spotted bass
Bullhead minnow	Largemouth bass
River carpsucker	White crappie
Bigmouth buffalo	Black crappie
Smallmouth buffalo	Greenside darter
Black buffalo	Tennessee snubnose darter
Northern hog sucker	Logperch
Spotted sucker	Sauger
Black redhorse	Walleye
River redhorse	Freshwater drum
Golden redhorse	
Shorthead redhorse	
Blue catfish	
Yellow bullhead	

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Threadfin Shad	Bluegill	Freshwater Drum	Total
1974	5	2,951	1,542	821	6,787
1975	3	69,465	31	712	92,673

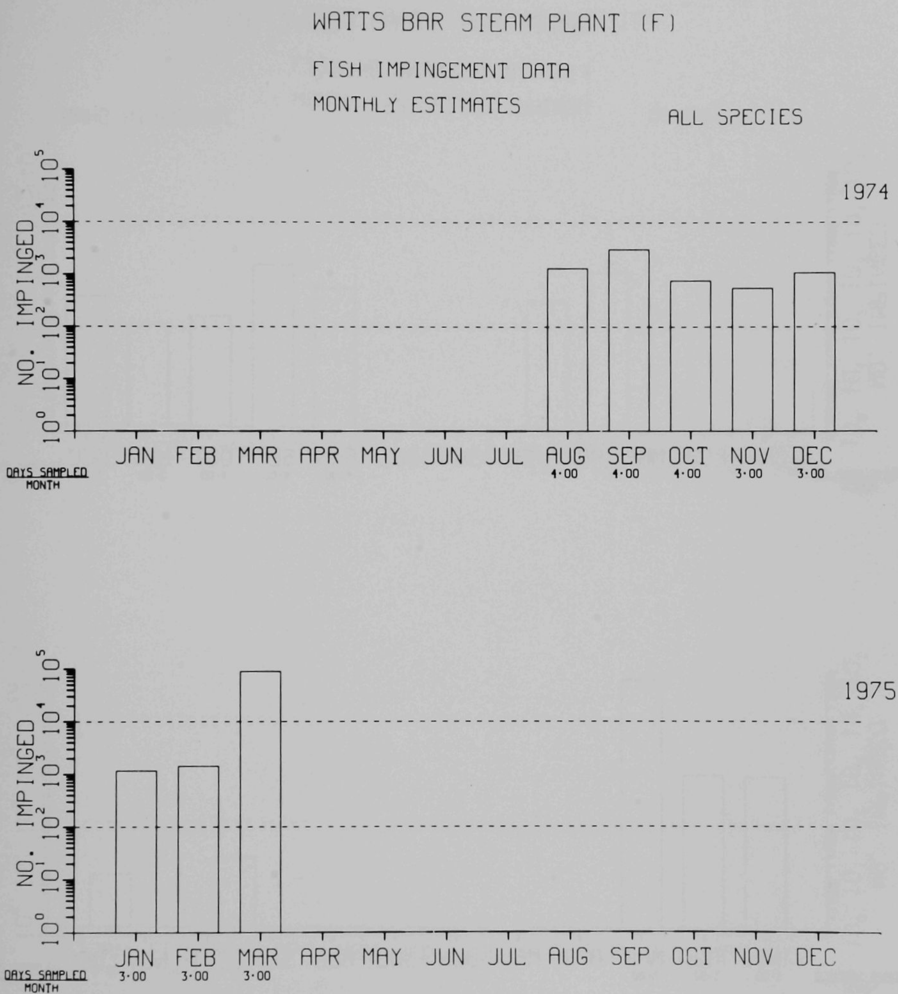


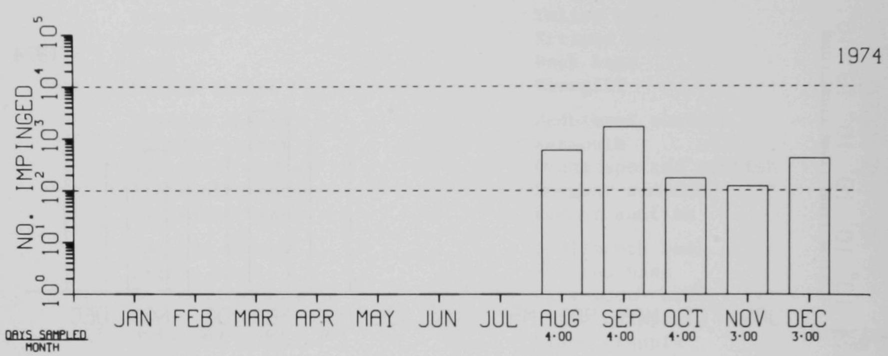
Fig. H1. Impingement Estimates.

WATTS BAR STEAM PLANT (F)

FISH IMPINGEMENT DATA

MONTHLY ESTIMATES

THREADFIN SHAD



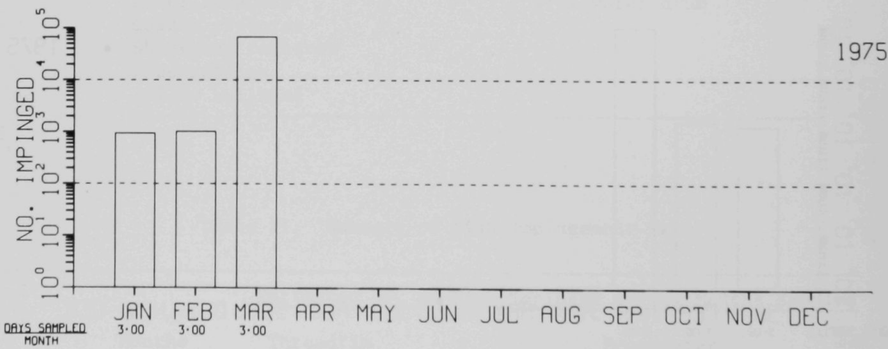


Fig. H2. Impingement Estimates.

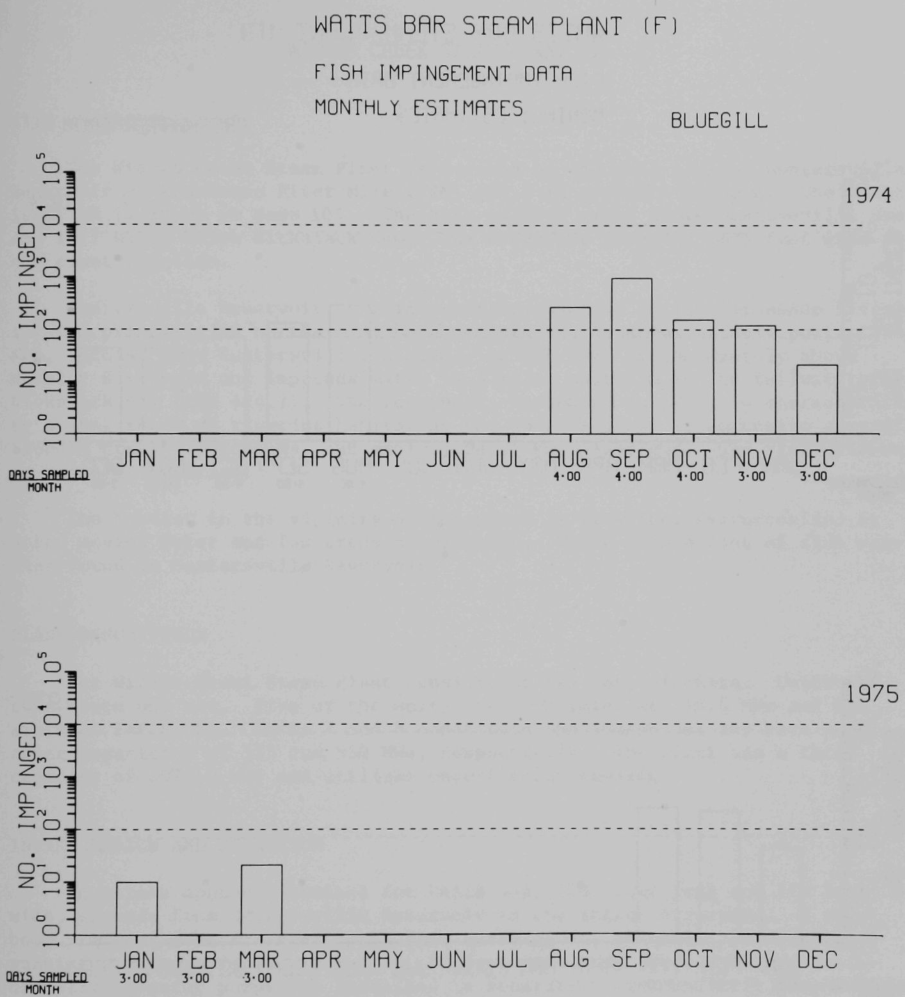


Fig. H3. Impingement Estimates.

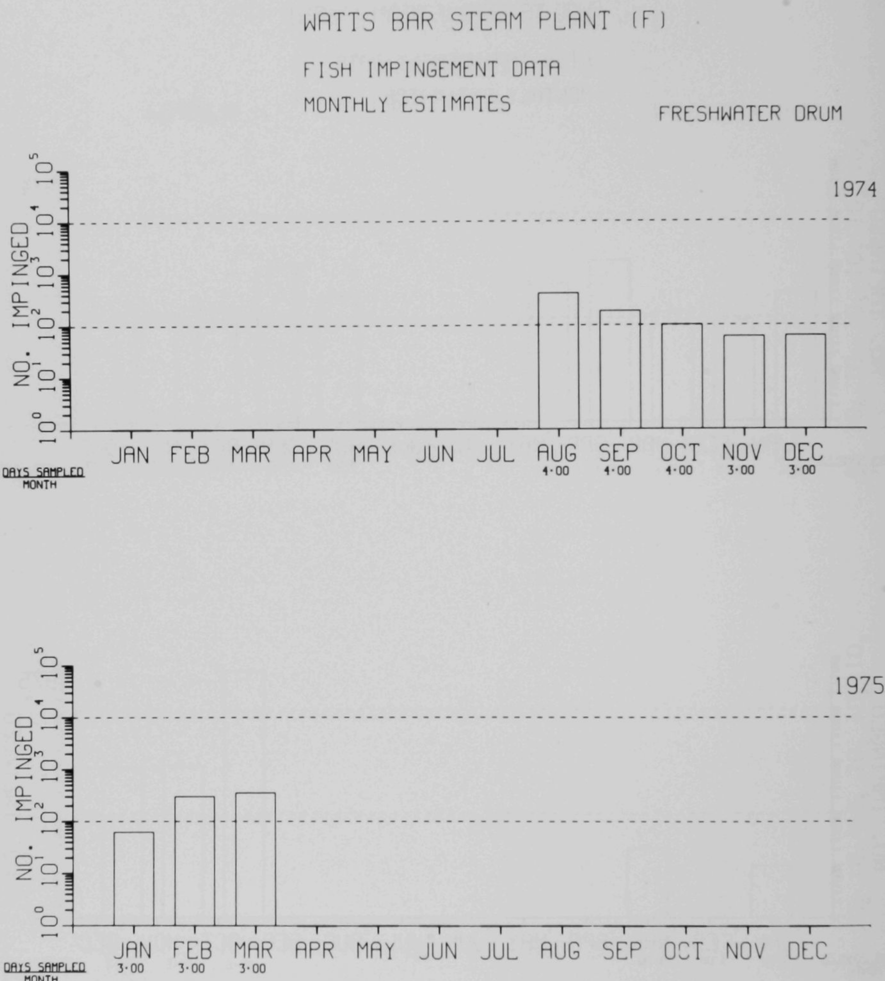


Fig. H4. Impingement Estimates.

WIDOWS CREEK STEAM PLANT (F)

SITE CHARACTERISTICS

The Widows Creek Steam Plant is located on the west bank of Guntersville Reservoir at Tennessee River Mile (TRM) 407.5 in northern Alabama. The plant location is shown on page 105. The site is 57.7 miles above Guntersville Dam and 16.7 miles below Nickajack Dam. The reservoir is about 1400 feet wide at the plant location.

Guntersville Reservoir, a mainstream impoundment on the Tennessee River located primarily in northern Alabama, covers 68,888 acres at full pool. The dam, located near Guntersville, Alabama, at TRM 349, is immediately above Wheeler Reservoir and impounds water 74.5 miles upstream to the tailwaters of Nickajack Dam (TRM 424.7). The reservoir, impounded in 1939, is characterized by a long reach of riverine habitat at the upper end and an extensive area of flooded creeks, overbanks, and embayments at the lower end. The reservoir has no major tributaries.[1]

The habitat in the vicinity of the plant is riverine, characterized by deep, moving water and few areas of overbank. Table I is a list of fish species found in Guntersville Reservoir.

PLANT DESCRIPTION

The Widows Creek Steam Plant consists of two sets of units. Units 1-6 constitute one set. Five of the units are each rated at 140.6 MWe and the sixth at 149.9 MWe. Units 7 and 8 constitute the second set and have generating capacities of 575 and 550 MWe, respectively. The plant has a total capacity of 1977.9 MWe and utilizes once-through cooling.

INTAKE DESIGN AND OPERATION

An intake approach channel for Units 1-6, 1100 feet long and 120 feet wide, extends from Guntersville Reservoir to the intake structure. A trash boom prevents most floating trash from entering the channel. The concrete pumping structure is 180 feet long, 53 feet wide, and 50 feet high. Twelve circulating-water pumps are installed in separate wells, and each pumpwell is preceded by an intake bay with a trash rack and a traveling screen. The design flow rate is 107,600 gpm for each of Units 1-4 and 92,500 gpm for each of Units 5 and 6. Velocities through the trash racks were measured at 0.28 fps to 1.55 fps with a mean velocity of 0.96 fps. Velocities in the approach channel ranged from 1.14 fps to 2.29 fps with an average of 1.79 fps.

Higher velocities were found throughout the water column in the deeper left side of the channel.[2]

For Units 7 and 8, the intake structure is located on the shoreline and draws water directly from the river rather than through an intake channel. The intake structure is 80 feet long, 96 feet wide, and 55 feet high. There are six circulating-water pumps for Units 7 and 8. Each pump is installed in a separate well preceded by trash racks and traveling screens. The design condenser flow rate is 227,000 gpm for Unit 7 and 250,000 gpm for Unit 8, bringing the total condenser flow rate for all eight units to 1,092,400 gpm. Velocities through the trash racks of Units 7 and 8 ranged from 0.83 fps to 2.22 fps with a mean of 1.41 fps.

IMPINGEMENT SAMPLING

Impingement samples were collected weekly between August 1974 and March 1975. At the beginning of a sample period, all traveling screens were rotated and washed. Twenty-four hours later, the screens were again rotated and washed. Impinged fish were collected and separated by species into length categories of integral multiples of 25 mm. Impingement counts were taken only from those screens through which water was being pumped at the end of the sample period.

DATA AVAILABILITY

Fish impingement data for the Widows Creek Steam Plant are available for 6 August 1974 through March 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing the total numbers of the three most abundant species as well as all species impinged at the Widows Creek Steam Plant. These totals are summarized in Table II.

Widows Creek Steam Plant offers a unique opportunity for comparison of two types of cooling-water-intake design: the shoreline versus the intake-channel type. The average number of fish impinged per intake-channel screen was 1.39 times greater (1.34 times greater for shad and 2.19 times greater for all species) than the average number on the shoreline screens, even though the fish were subjected to an average velocity 1.47 times greater at the shoreline intake than at the channel intake. In addition, although pumps for Units 7 and 8 accounted for about 47% of the water removed from Guntersville Reservoir, only about 25% of the numbers or biomass of fish were impinged on the corresponding screens.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCES

1. "Impingement at Widows Creek Steam Plant." Tennessee Valley Authority. (Undated.)

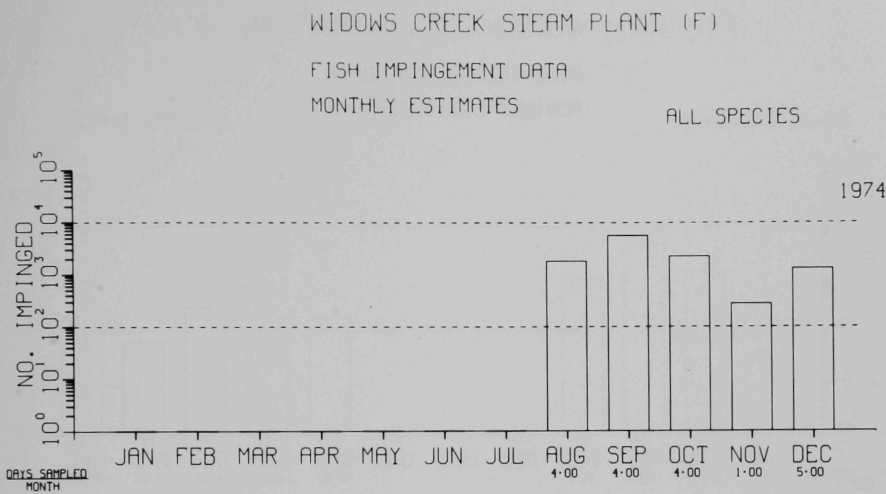
2. "Effects of Widows Creek Steam Plant on the Fish Populations of Guntersville Reservoir." Tennessee Valley Authority - Division of Forestry, Fisheries, and Wildlife Development. 6 December 1974.

Table I. Fish Species Collected in Cove Rotenone Samples, Guntersville Reservoir, 1949 to 1971

Bowfin	Blue catfish
Spotted gar	Black bullhead
Longnose gar	Yellow bullhead
Shortnose gar	Channel catfish
Skipjack herring	Flathead catfish
Gizzard shad	Blackstripe topminnow
Threadfin shad	Mosquitofish
Goldfish	Brook silverside
Carp	White bass
Golden shiner	Yellow bass
Emerald shiner	Redbreast sunfish
Whitetail shiner	Green sunfish
Spotfin shiner	Pumpkinseed
Steelcolor shiner	Warmouth
Suckermouth minnow	Orangespotted sunfish
Bluntnose minnow	Bluegill
Fathead minnow	Longear sunfish
Bullhead minnow	Redear sunfish
River carpsucker	Smallmouth bass
Quillback	Spotted bass
Smallmouth buffalo	Largemouth bass
Bigmouth buffalo	White crappie
Black buffalo	Black crappie
Spotted sucker	Fantail darter
Golden redhorse	Redline darter
	Logperch
	Sauger
	Freshwater drum

Table II. Summary of Fish Impingement Data

		Estimated No. of Fish Impinged during Months Sampled			
Year	No. of Months Sampled	Gizzard Shad	Threadfin Shad	Freshwater Drum	Total
1974	5	771	8,014	943	11,393
1975	3	286	14,401	2,725	19,154



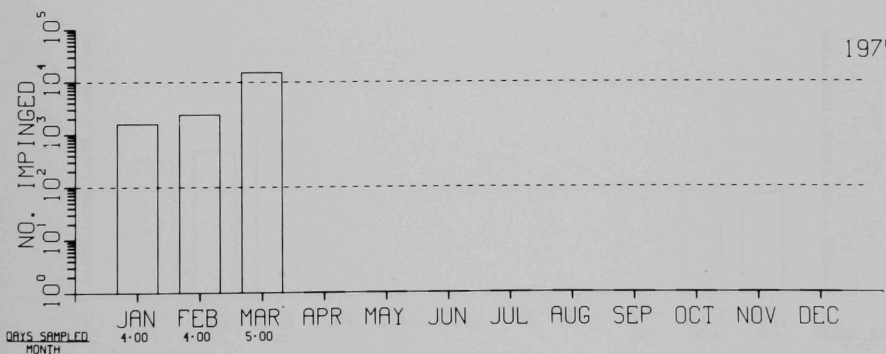


Fig. H1. Impingement Estimates.

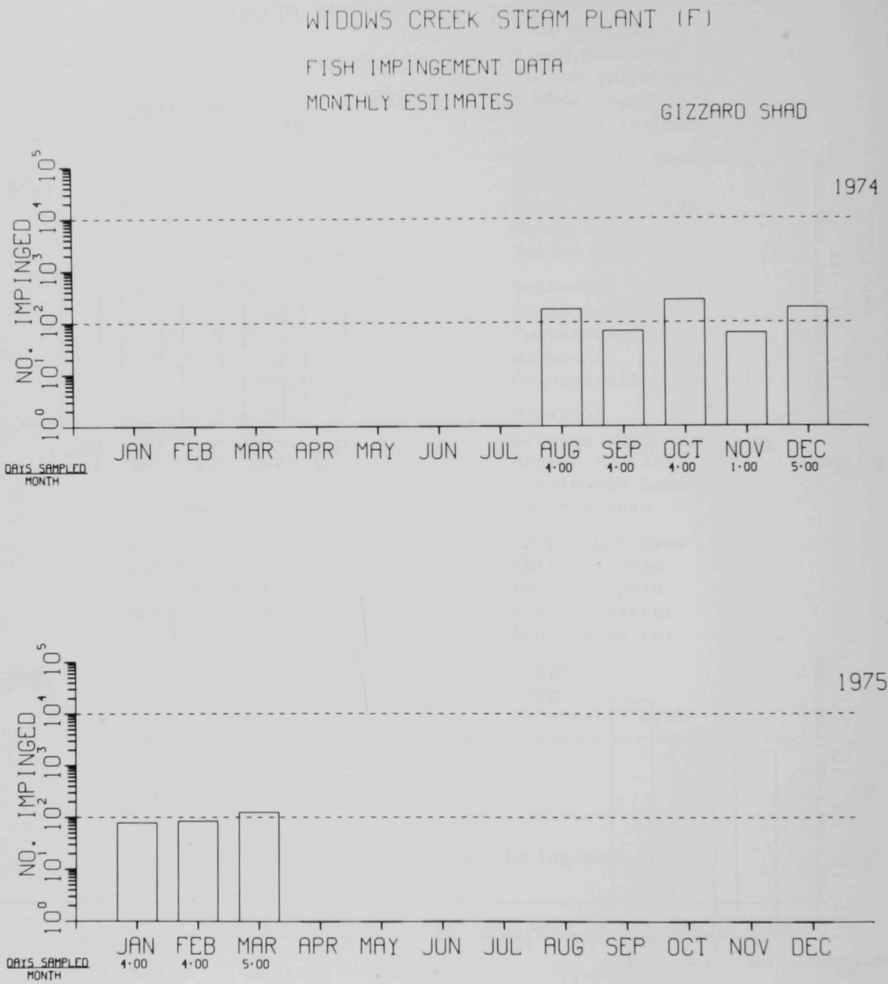


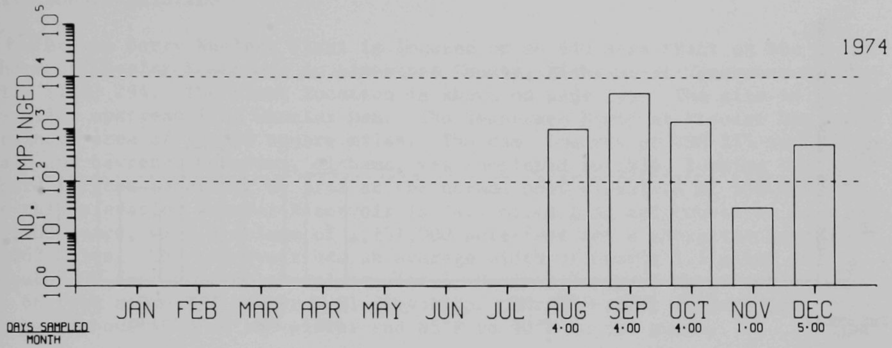
Fig. H2. Impingement Estimates.

WIDOWS CREEK STEAM PLANT (F)

FISH IMPINGEMENT DATA

MONTHLY ESTIMATES

THREADFIN SHAD



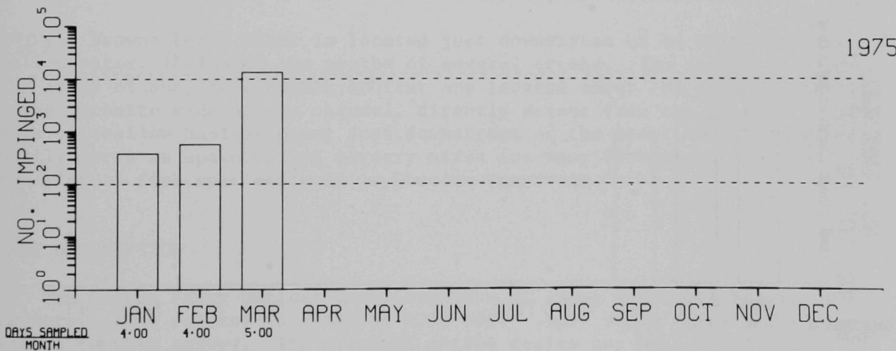


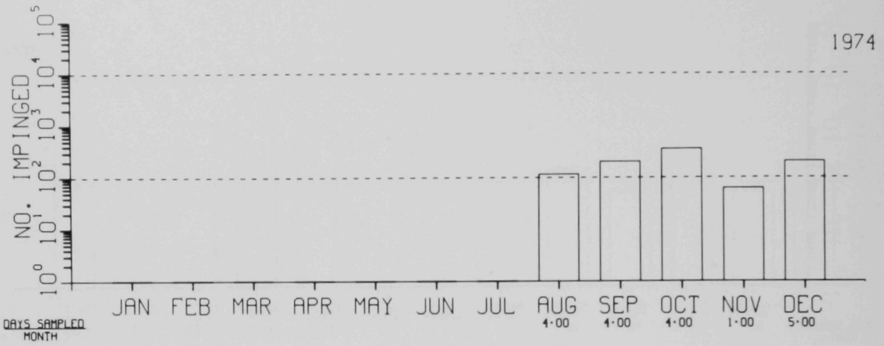
Fig. H3. Impingement Estimates.

WIDOWS CREEK STEAM PLANT (F)

FISH IMPINGEMENT DATA

MONTHLY ESTIMATES

FRESHWATER DRUM



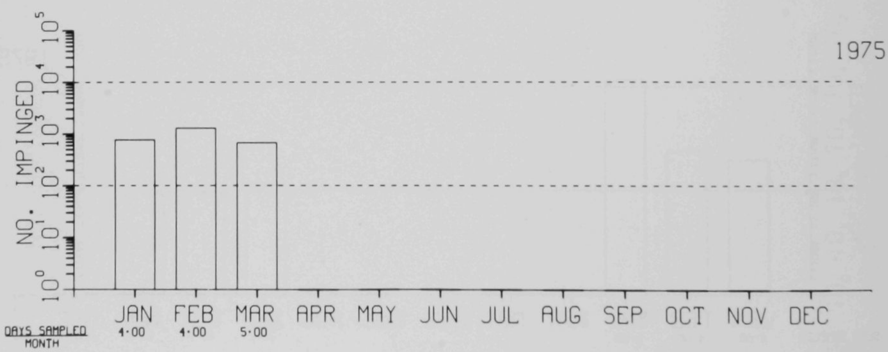


Fig. H4. Impingement Estimates.

BROWNS FERRY NUCLEAR PLANT (N)

SITE CHARACTERISTICS

Browns Ferry Nuclear Plant is located on an 840-acre tract on the north shore of Wheeler Reservoir in Limestone County, Alabama, at Tennessee River Mile (TRM) 294. The plant location is shown on page 105. The site is located 19 miles upstream from Wheeler Dam. The Tennessee River at Wheeler Dam has a drainage area of 29,590 square miles. The dam, located at TRM 275 in Lauderdale and Lawrence Counties, Alabama, was completed in 1936, forming TVA's third largest reservoir by area at the normal pool elevation of 558 feet MSL. At this elevation Wheeler Reservoir is 74.1 miles long and covers an area of 67,100 acres, with a volume of 1,131,000 acre-feet and a shoreline length of 1,063 miles. The reservoir has an average width of nearly 1.5 miles and is about 7300 feet wide at the plant site.[1] Maximum depth of Wheeler Reservoir is 66 feet at normal summer pool elevation. Surface-water temperature ranges between about 40°F in the winter and 85°F to 90°F in the summer.

Wheeler Reservoir is classified as a highly productive, warm-water aquatic environment. Benthic habitats in the reservoir range from deposits of finely divided silts to river-channel cobble and bedrock. The most extensive benthic habitat is composed of fine-grained brown silt, which is deposited both in the old river channel and on the former overbank areas. The overbank areas are far more extensive than the old river channel and are very productive.

The Browns Ferry Plant is located just downstream of an extensive area of shallow water, including the mouths of several creeks. Two additional extensive areas of shallow-overbank habitat are located about two miles downstream on the opposite side of the channel, directly across from the plant. Limited areas of shallow habitat occur just downstream of the plant site. Such areas usually serve as spawning and nursery sites for many fish species.[2] Table I is a list of fish species found in Wheeler Reservoir.

PLANT DESCRIPTION

The Browns Ferry Nuclear Plant consists of three identical boiling water reactors. Each reactor is rated at 1098 MWe.[2] Only Units 1 and 2 were considered in this survey. The original intake design has been modified to include a multigate structure to permit combined-cycle operation.[3]

INTAKE DESIGN AND OPERATION

Cooling water is withdrawn from Wheeler Reservoir through a multigate structure consisting of three bays, each 40 feet wide by 24 feet high. During closed-cycle operation, a 20-foot-high gate is lowered into each bay leaving an opening of four feet by 40 feet for passage of makeup water. Velocity through these openings in this mode is 0.67 fps. During the open and helper modes of operation, the gates are lifted leaving a 40- by 20-foot opening for each bay. Maximum velocities through these openings are during open-cycle operation and are about 1.6 fps, 1.0 fps, and 0.5 fps for three-, two-, and one-unit operation, respectively. These velocities are independent of reservoir elevation.

The intake structure consists of 18 bays, each having a vertical traveling screen. The maximum average velocity through each bay is about 1.4 fps and is independent of reservoir level. Six circulating-water pumps, each rated at 220,000 gpm, carry the water through tunnels to the condensers. Total flow through the condensers is 1,320,000 gpm.

IMPINGEMENT SAMPLING

During impingement sampling at Browns Ferry, one screen was selected and washed, and all fish on the screen were collected, identified, enumerated, measured, and weighed. The total impingement reported in the monthly reports was estimated by extrapolating the results of the selected-screen count by a weighting factor. The weighting factor is derived from bimonthly studies in which all screens were cleaned and sampled for two consecutive days.

DATA AVAILABILITY

Fish impingement data for the Browns Ferry Nuclear Plant are available for February 1974 through February 1976.

IMPINGEMENT DATA SUMMARY

Figures H1 through H8 are histograms representing the three most abundant species as well as all species impinged at the Browns Ferry Plant. Figures H1 through H4 were obtained using the weighting factor described above, whereas Figures H5 through H8 were derived using simple extrapolations from the sample screen. It should be noted that differences in number of days sampled may vary between the two sets of data. The reason for this is that not all samples were broken down into species categories, and some days were thus eliminated. Tables II and III summarize the totals obtained by the two methods.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCES

1. "Draft Environmental Statement for Browns Ferry Nuclear Plant, Units 1, 2, and 3." Vol. 2. Tennessee Valley Authority. 14 July 1971.

2. Personal communication with Allen Qualls of the Tennessee Valley Authority. 19 May 1976.

3. "Final Environmental Statement for Browns Ferry Nuclear Plant, Units 1, 2, and 3." Vol. 1. Tennessee Valley Authority. 1 September 1972.

Table I. Fishes of Wheeler Reservoir

Largemouth bass	Smallmouth buffalo
Smallmouth bass	Channel catfish
Spotted bass	Flathead catfish
White bass	Carp
Yellow bass	Freshwater drum
White crappie	Spotted sucker
Black crappie	Northern hog sucker
Bluegill	Golden redhorse
Warmouth	Black redhorse
Longear sunfish	River redhorse
Green sunfish	Blue catfish
Redear sunfish	Paddlefish
Rock bass	Threadfin shad
Sauger	Gizzard shad
Longnose gar	Orangespotted sunfish
Shortnose gar	Logperch
Spotted gar	Brook silverside
Skipjack herring	Golden shiner
Mooneye	Emerald shiner
Bigmouth buffalo	Bluntnose minnow
	Fantail darter
	Blackstripe topminnow

Table II. Summary of Fish Impingement Data Using Weighting Factor

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Shad and Herring	Freshwater Drum	Catfish	Total
1974	11	3,288,592	220,689	32,036	3,162,091
1975	12	5,209,179	183,320	25,803	5,531,509
1976	2	592,908	28,861	3,150	639,459

Table III. Summary of Fish Impingement Data Using Sample-Screen Extrapolations

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Shad and Herring	Freshwater Drum	Catfish	Total
1974	11	596,040	43,579	6,355	658,404
1975	12	645,259	27,291	3,739	691,778
1976	2	76,035	5,100	526	83,396

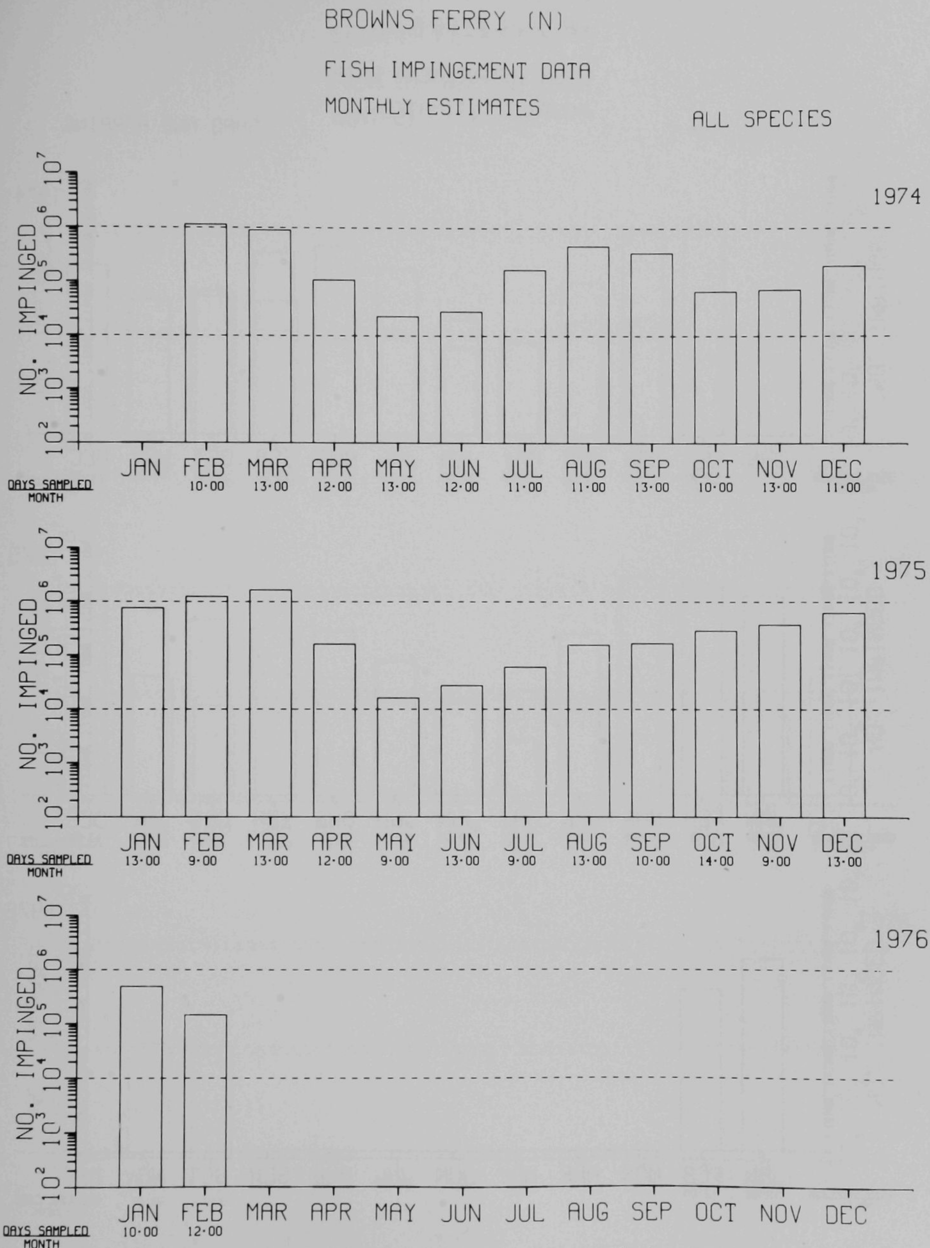


Fig. H1. Impingement Estimates Using Weighting Factor.

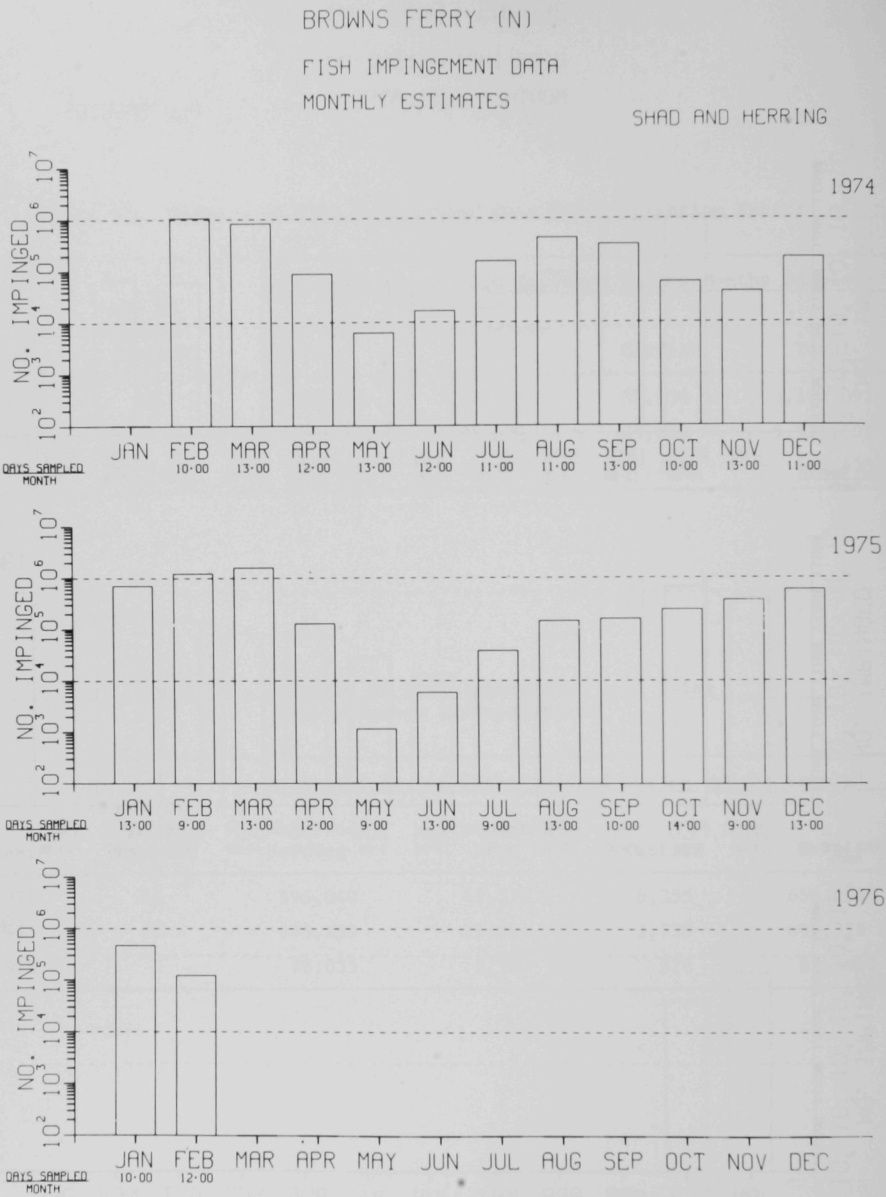


Fig. H2. Impingement Estimates Using Weighting Factor.

BROWNS FERRY (N)

FISH IMPINGEMENT DATA

MONTHLY ESTIMATES

FRESHWATER DRUM

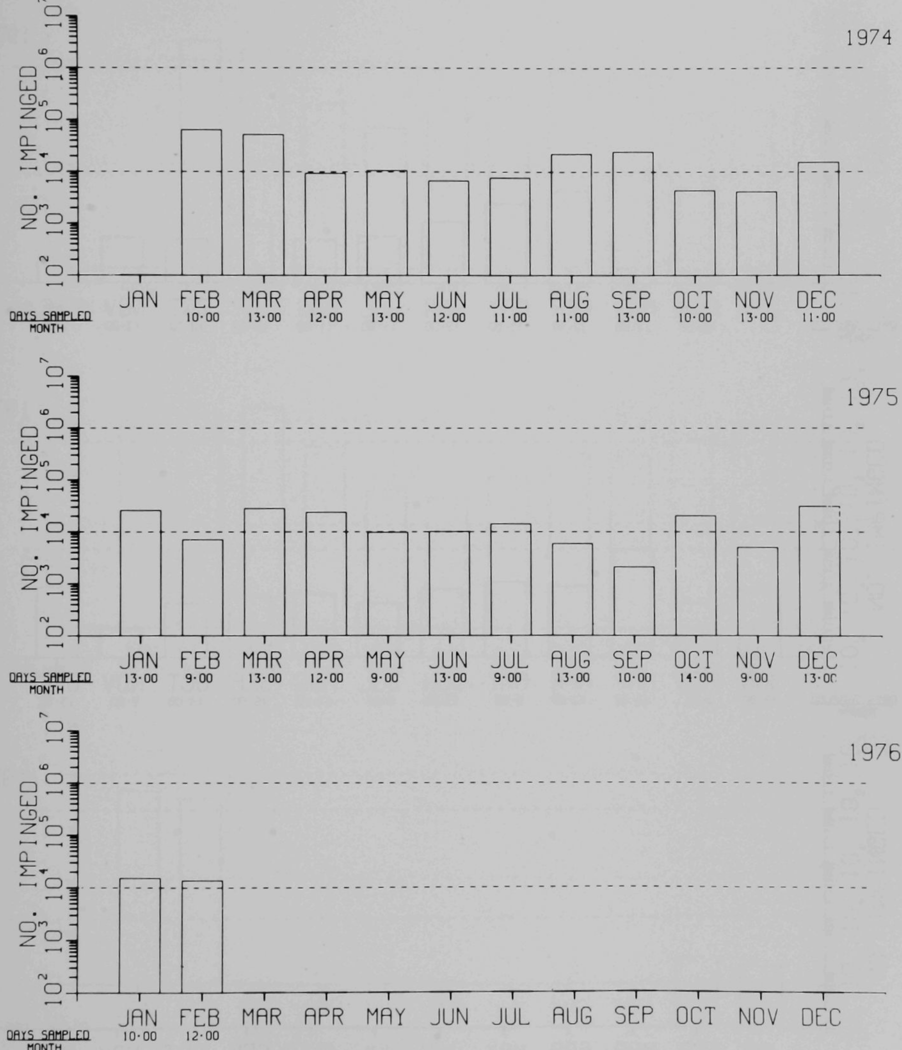


Fig. H3. Impingement Estimates Using Weighting Factor.

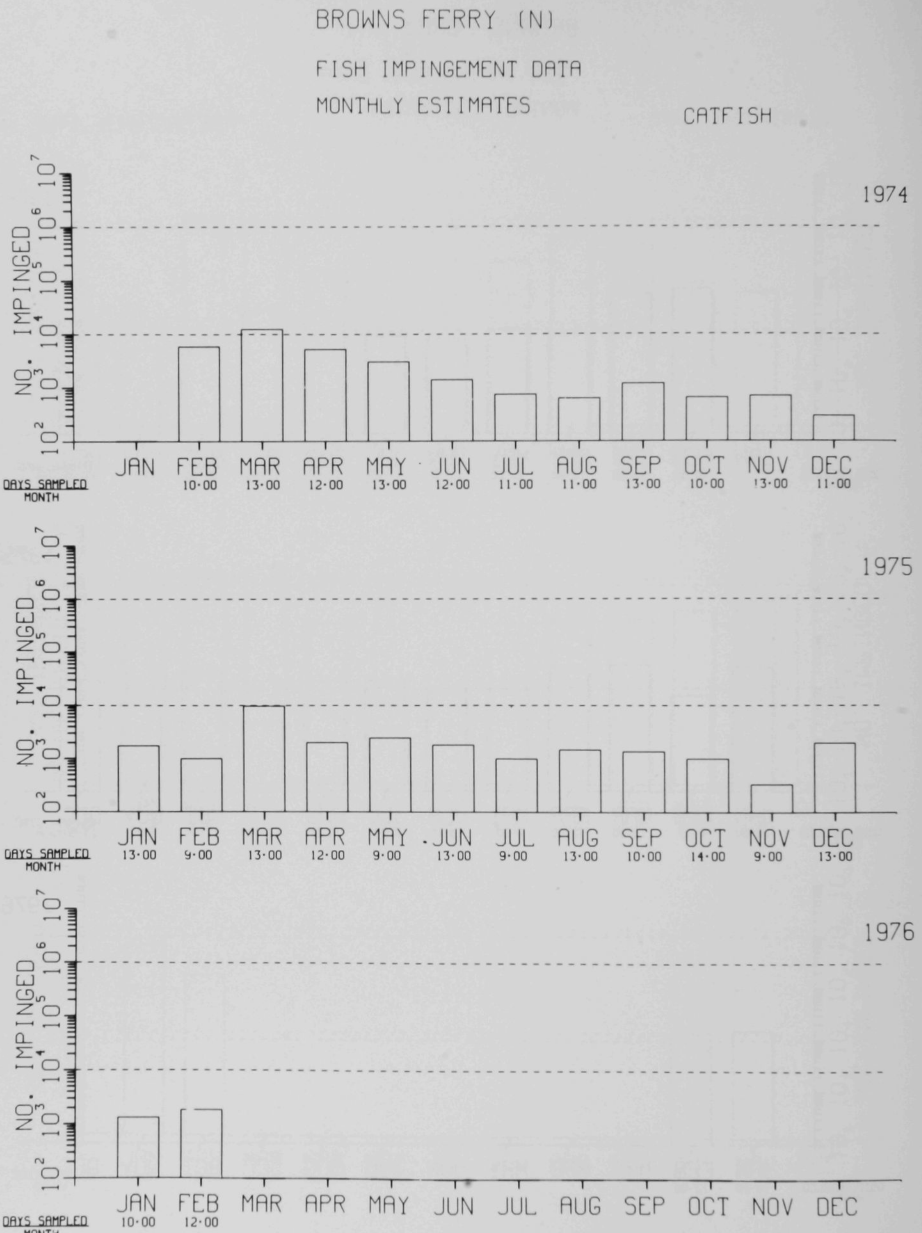


Fig. H4. Impingement Estimates Using Weighting Factor.

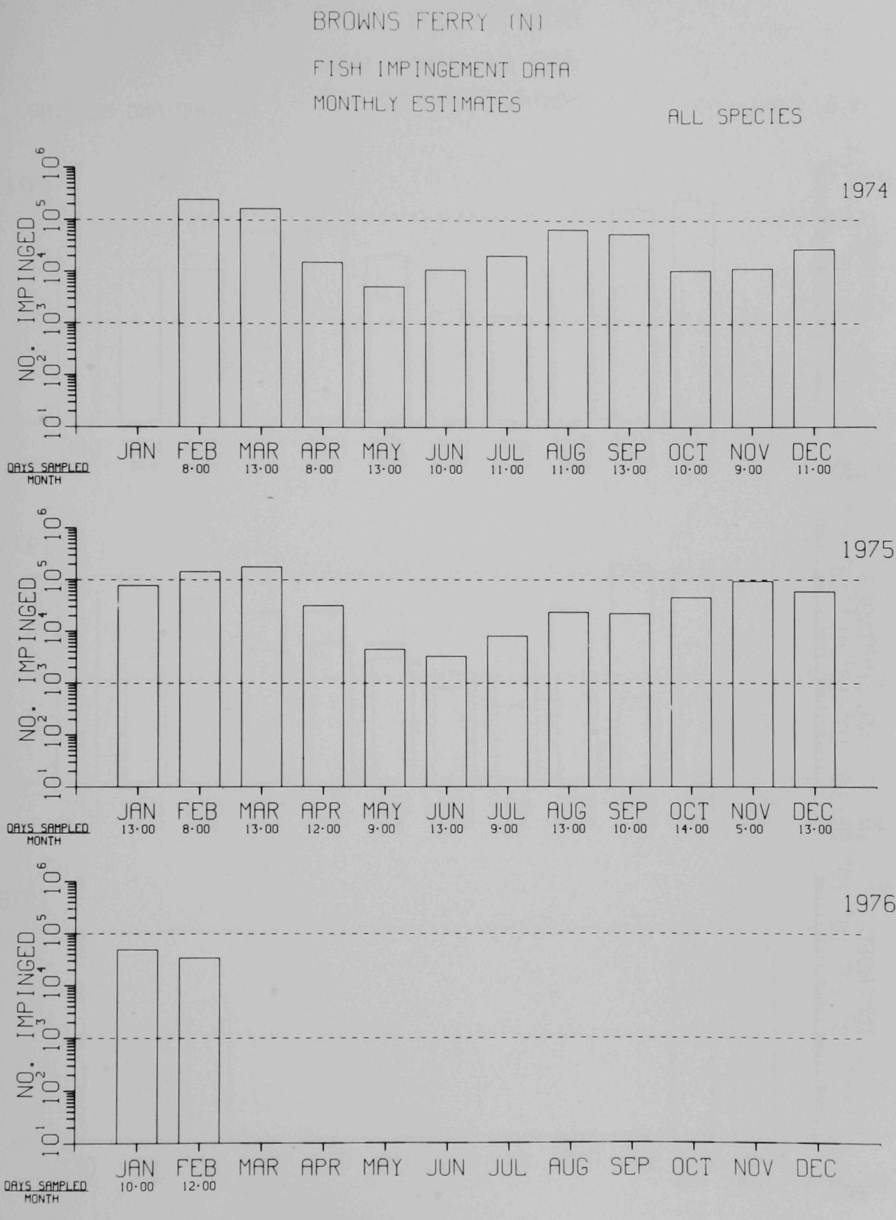


Fig. H5. Impingement Estimates Using Sample-Screen Extrapolations.

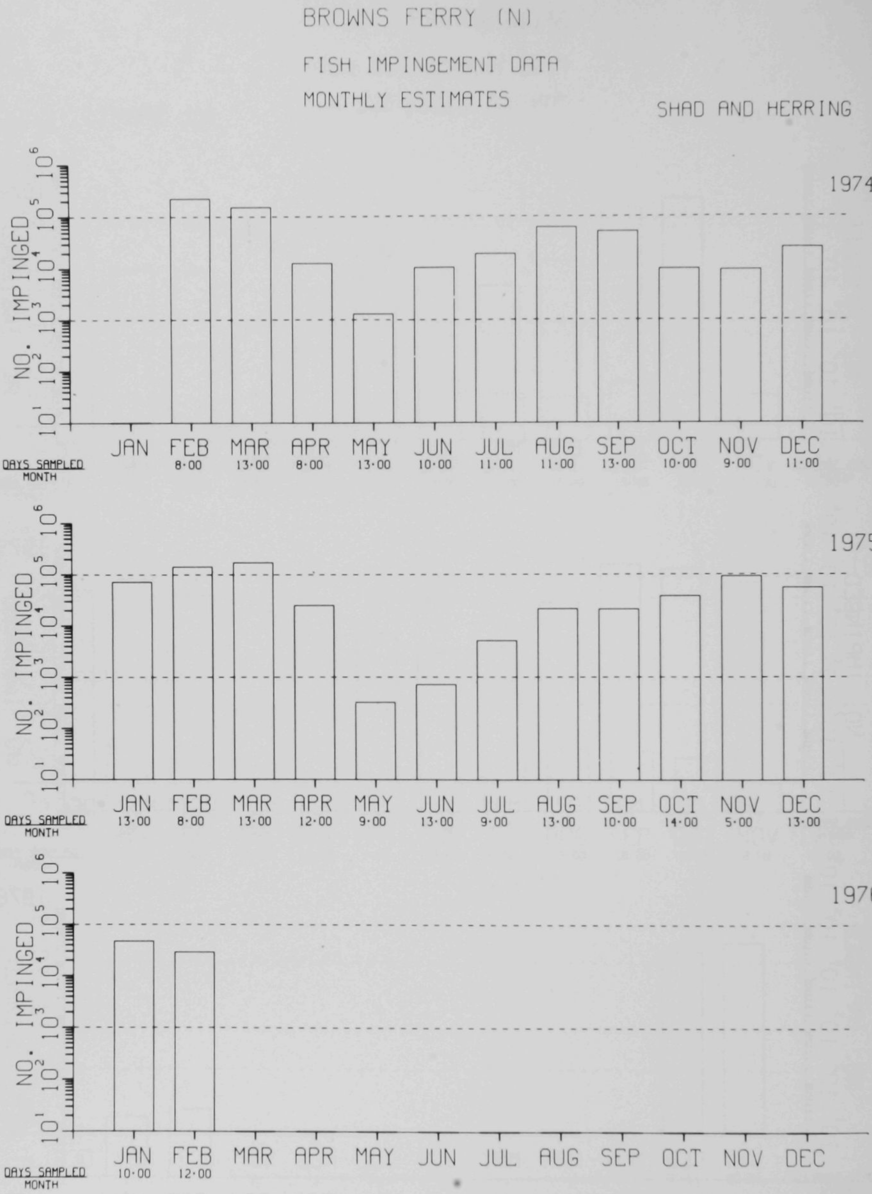


Fig. H6. Impingement Estimates Using Sample-Screen Extrapolations.

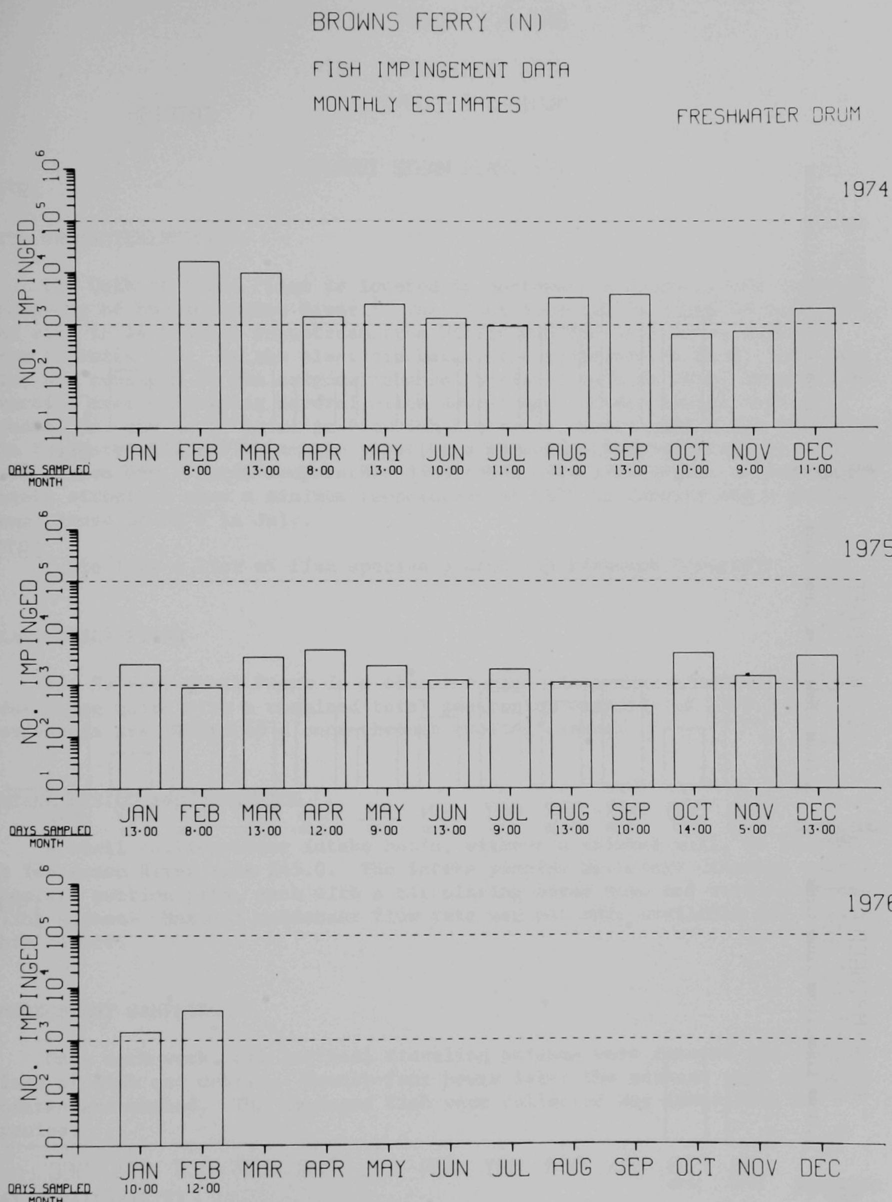


Fig. H7. Impingement Estimates Using Sample-Screen Extrapolations.

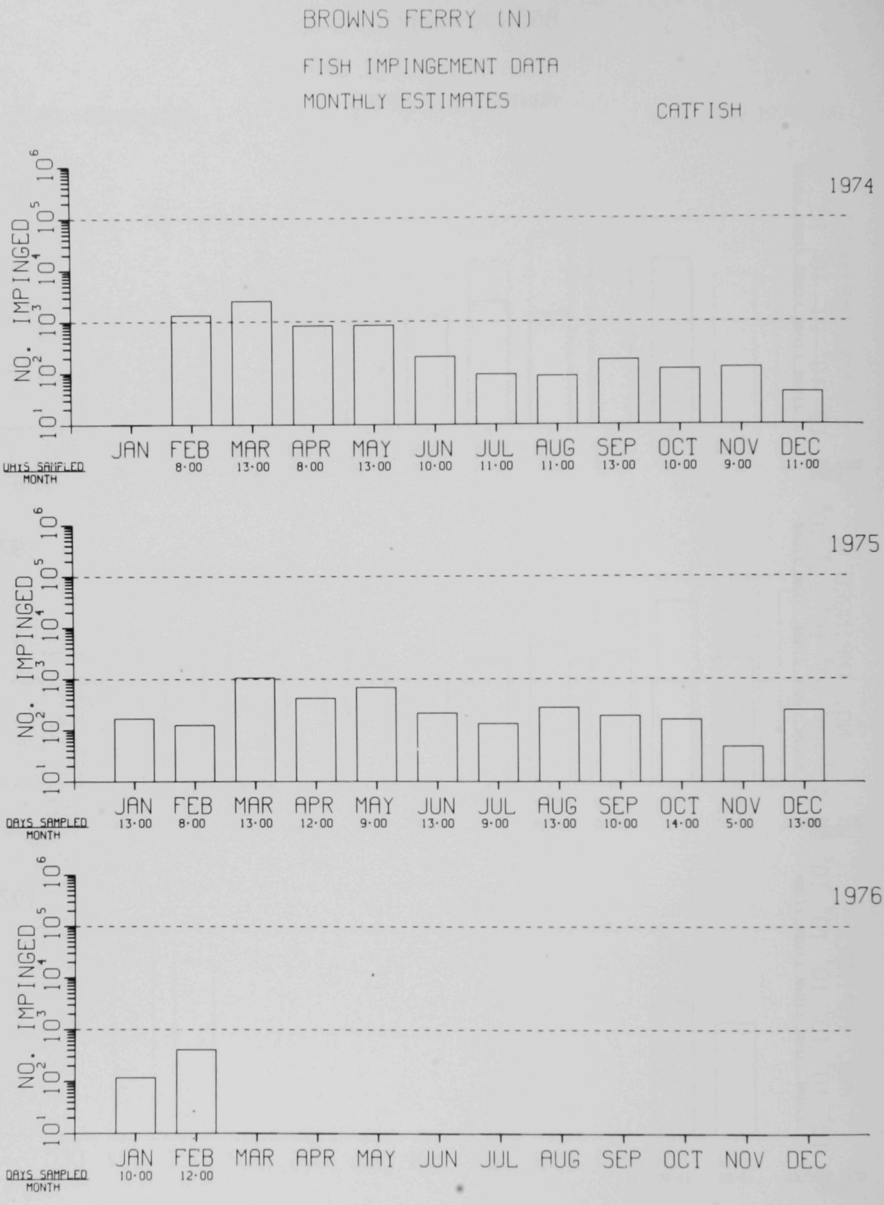


Fig. H8. Impingement Estimates Using Sample-Screen Extrapolations.

COLBERT STEAM PLANT (F)

SITE CHARACTERISTICS

The Colbert Steam Plant is located in northwest Alabama on the Pickwick Reservoir of the Tennessee River.[1] The plant location is shown on page 105. The site is 14.5 miles downstream from Wilson Dam and 38.3 miles upstream from Pickwick Dam. At the plant discharge, the reservoir is about 3400 feet wide and consists of the original channel bordered on both sides by shallow-overbank areas extending several miles downstream. Under normal operating conditions, the water level in Pickwick Reservoir varies only about six feet. The Tennessee River flow at the plant site is controlled primarily by releases from Wilson Dam. Water-temperature data taken over a five-year period at the intake structure show a minimum temperature of 38°F in January and a maximum temperature of 86°F in July.

Table I is a list of fish species present in Pickwick Reservoir.

PLANT DESCRIPTION

The Colbert Steam Plant is a fossil-fueled plant that consists of five generating units with a combined total generating capacity of 1396.5 MWe. Condensers are cooled by a once-through cooling system.

INTAKE DESIGN AND OPERATION

A small cooling-water intake basin, without a skimmer wall, is located at Tennessee River Mile 245.0. The intake pumping structure contains twelve separate suction pits, each with a circulating-water pump and vertical traveling screen. Maximum condenser flow rate was not made available for use in this report.

IMPINGEMENT SAMPLING

Once each week, all vertical traveling screens were rotated and washed clean of fish and debris. Twenty-four hours later the screens were again rotated and washed. The impinged fish were collected and identified to species.

DATA AVAILABILITY

Fish impingement data for the Colbert Steam Plant are available for August 1974 through March 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing the total numbers of the three most abundant species as well as all species impinged at the Colbert Steam Plant. These totals are summarized in Table II.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCE

1. "Summary of the Impact of Colbert Steam Plant upon the Aquatic Ecosystem of Pickwick Reservoir." Tennessee Valley Authority. August 1975.

Table I. Fish Species Collected in Pickwick Reservoir

Spotted gar	Blue catfish
Longnose gar	Yellow bullhead
Shortnose gar	Brown bullhead
American eel	Channel catfish
Skipjack herring	Tadpole madtom
Gizzard shad	Flathead catfish
Threadfin shad	Blackstripe topminnow
Mooneye	Mosquitofish
Chain pickerel	Brook silverside
Grass pickerel	White bass
Carp	Yellow bass
Golden shiner	Rock bass
Emerald shiner	Green sunfish
Spotfin shiner	Warmouth
Whitetail shiner	Orangespotted sunfish
Spottail shiner	Bluegill
Striped shiner	Longear sunfish
Common shiner	Redear sunfish
Bigeye chub	Smallmouth bass
Stoneroller	Spotted bass
Bluntnose minnow	Largemouth bass
Fathead minnow	White crappie
Bullhead minnow	Black crappie
River carpsucker	Rainbow darter
Quillback	Fantail darter
Highfin carpsucker	Johnny darter
White sucker	Redline darter
Northern hog sucker	Logperch
Smallmouth buffalo	Longhead darter
Bigmouth buffalo	Sauger
Spotted sucker	Freshwater drum
River redhorse	
Black redhorse	
Golden redhorse	
Shorthead redhorse	

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Threadfin Shad	Gizzard Shad	Skipjack Herring	Total
1974	5	27,051	319	1,243	40,552
1975	3	132,532	3,559	13,732	160,809

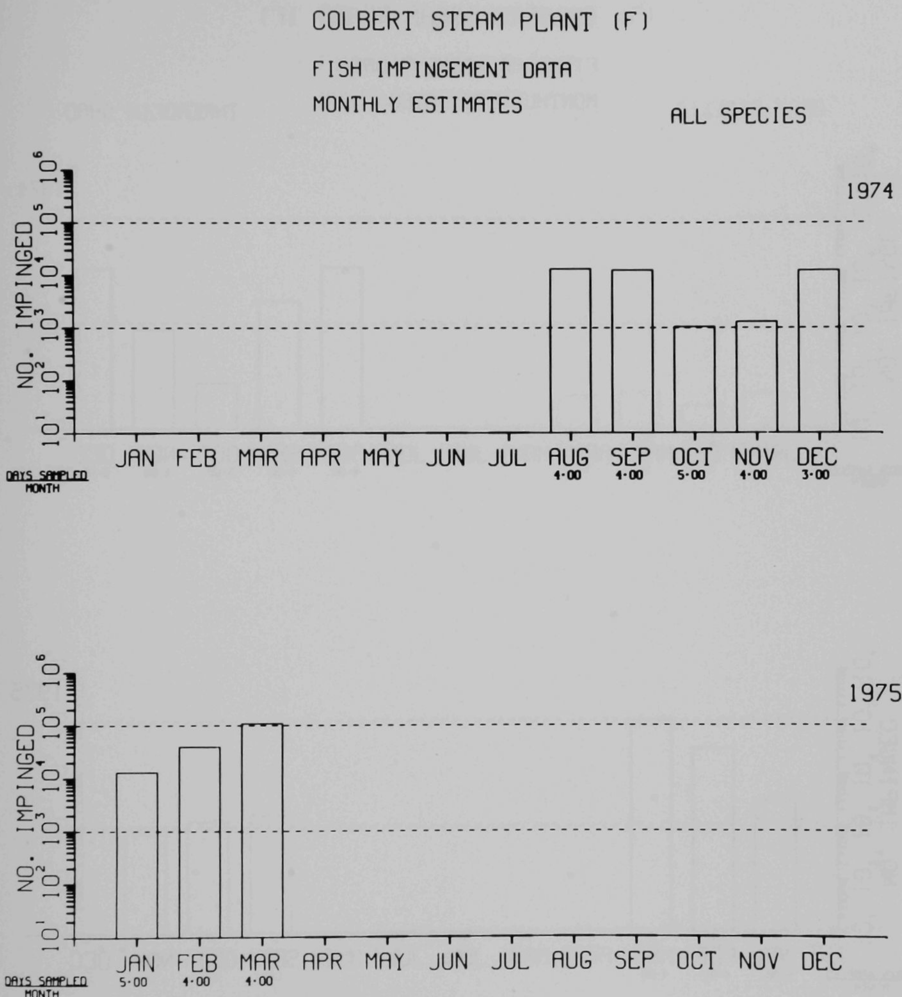


Fig. H1. Impingement Estimates.

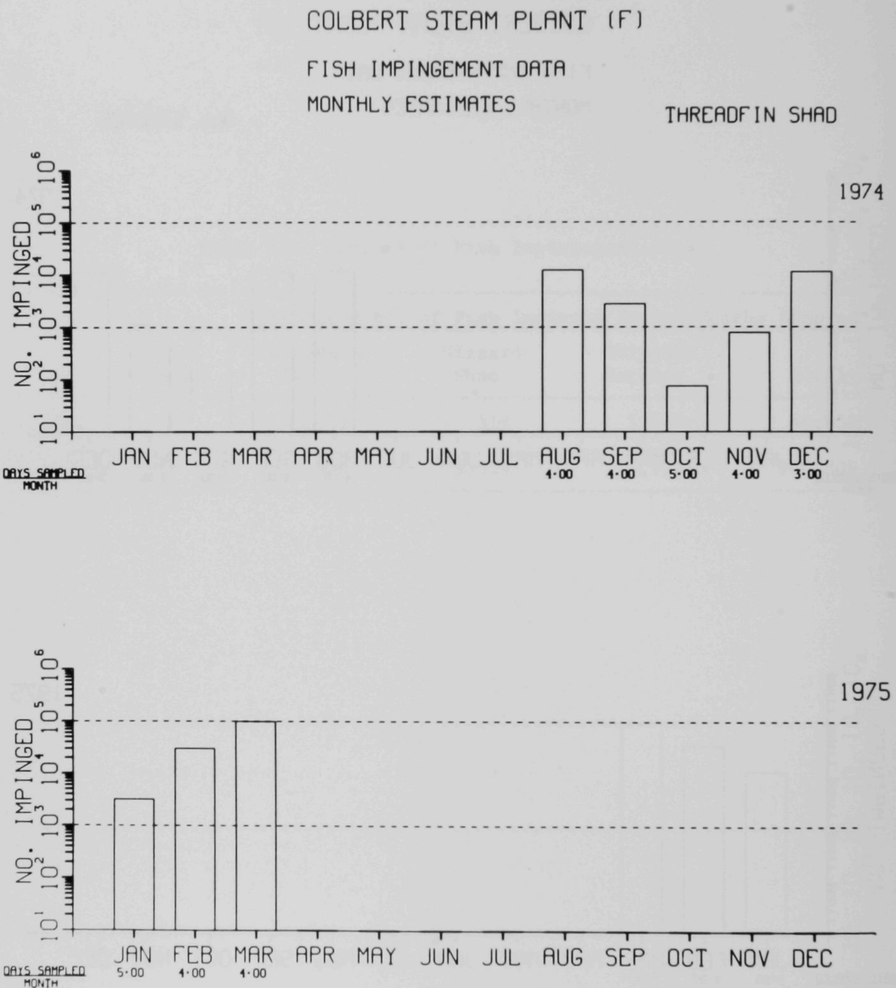


Fig. H2. Impingement Estimates.

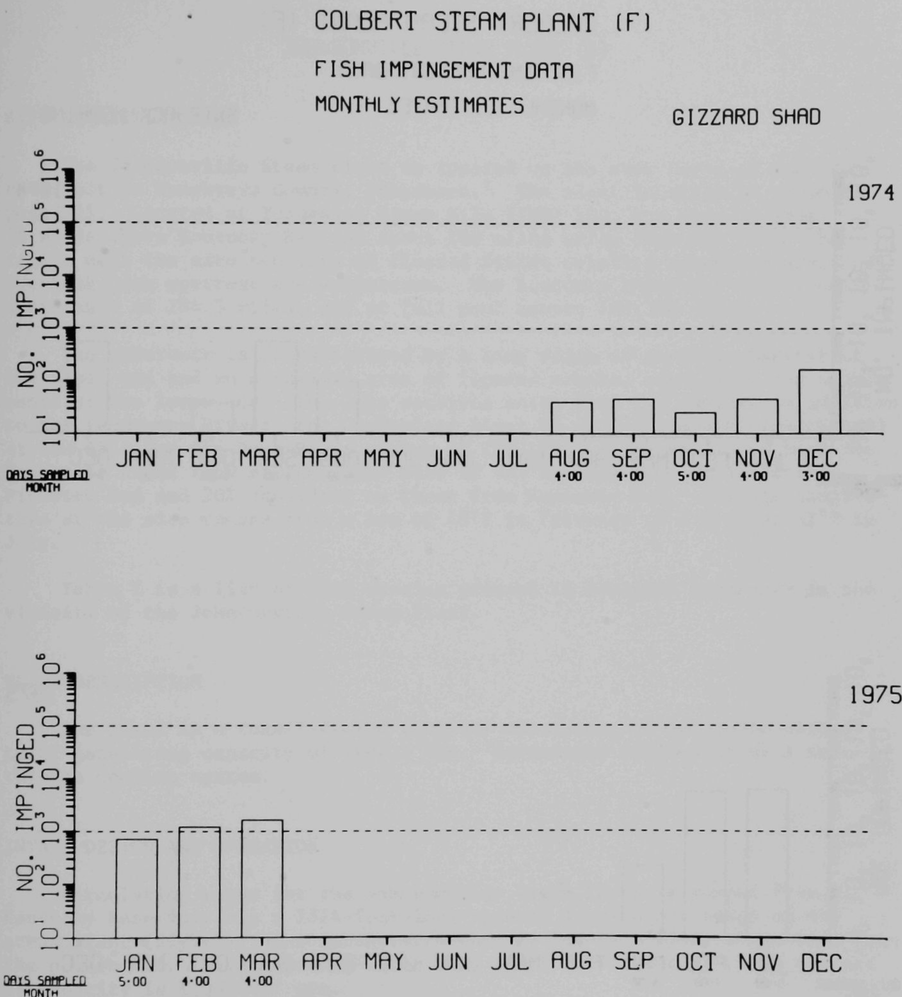


Fig. H3. Impingement Estimates.

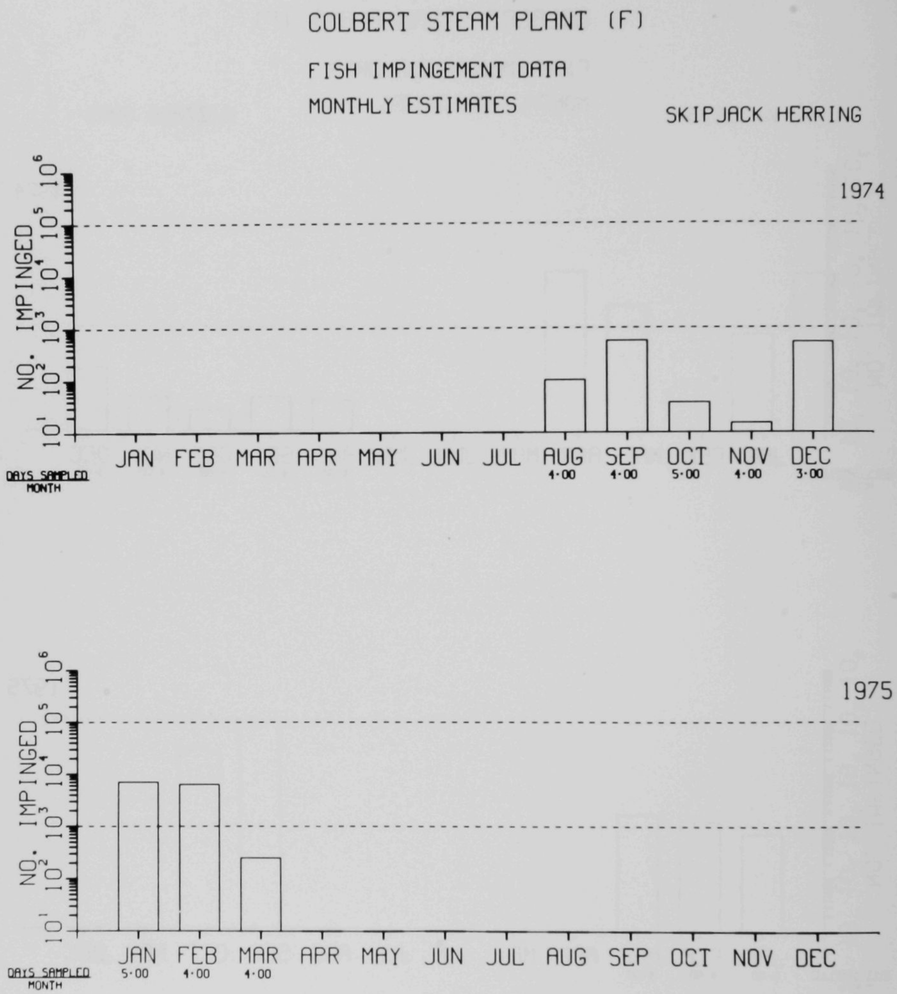


Fig. H4. Impingement Estimates.

JOHNSONVILLE STEAM PLANT (F)

SITE CHARACTERISTICS

The Johnsonville Steam Plant is located on the east shore of Kentucky Reservoir in Humphreys County, Tennessee.[1] The plant location is shown on page 105. Located at Tennessee River Mile (TRM) 100, the site is about 78 miles above Kentucky Dam and about 100 miles below Pickwick Dam. The region near the site consists of flooded fields creating extensive areas of overbank both upstream and downstream. The Kentucky Reservoir stretches for a distance of 184.3 miles, and at full pool covers 158,300 acres.

The reservoir is characterized by a long reach of riverine habitat at the upper end and an extensive area of flooded creeks, overbanks, and embayments at the lower end. The lake receives water from two sources in addition to the Tennessee River: the Cumberland River by way of a navigation channel at TRM 25.4 and the Duck River system at TRM 111. It is estimated that the Tennessee River flow at the plant site is 80% dependent on releases from Pickwick Dam and 20% dependent on those from Kentucky Dam. Average temperature at the site ranges from a low of 49°F in February to a high of 81°F in July.

Table I is a list of fish species present in Kentucky Reservoir in the vicinity of the Johnsonville Steam Plant.

PLANT DESCRIPTION

The plant is a fossil-fueled facility consisting of ten units with a total generating capacity of 1485.2 MWe. Condensers are cooled by a once-through cooling system.

INTAKE DESIGN AND OPERATION

Circulating water for the Johnsonville Steam Plant is pumped from Kentucky Reservoir via a 1574-foot-long channel located southwest of the steam plant (Fig. 1). The intake structure is located 525 feet upstream from the powerhouse. Total cooling-water flow required for the plant to operate at capacity is 1,030,067 gpm.

IMPINGEMENT SAMPLING

Once each week all vertical traveling screens were rotated and washed clean of fish and debris. Twenty-four hours later the screens were again rotated and washed. The impinged fish were collected and separated by species into length categories of integral multiples of 25 mm. Impingement counts were taken only from those screens through which water was being pumped at the end of the sample period.[2]

DATA AVAILABILITY

Impingement data for the Johnsonville Steam Plant are available for July 1974 through March 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing the total numbers of the three most abundant species as well as all species impinged at the Johnsonville Steam Plant. These totals are summarized in Table II.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCES

1. "Effects of Johnsonville Steam Plant on the Fish Populations of Kentucky Reservoir." Tennessee Valley Authority - Division of Forestry, Fisheries, and Wildlife Development. 6 December 1974.

2. "Impingement Study Plan - Johnsonville Steam Plant." Tennessee Valley Authority. (Undated.)

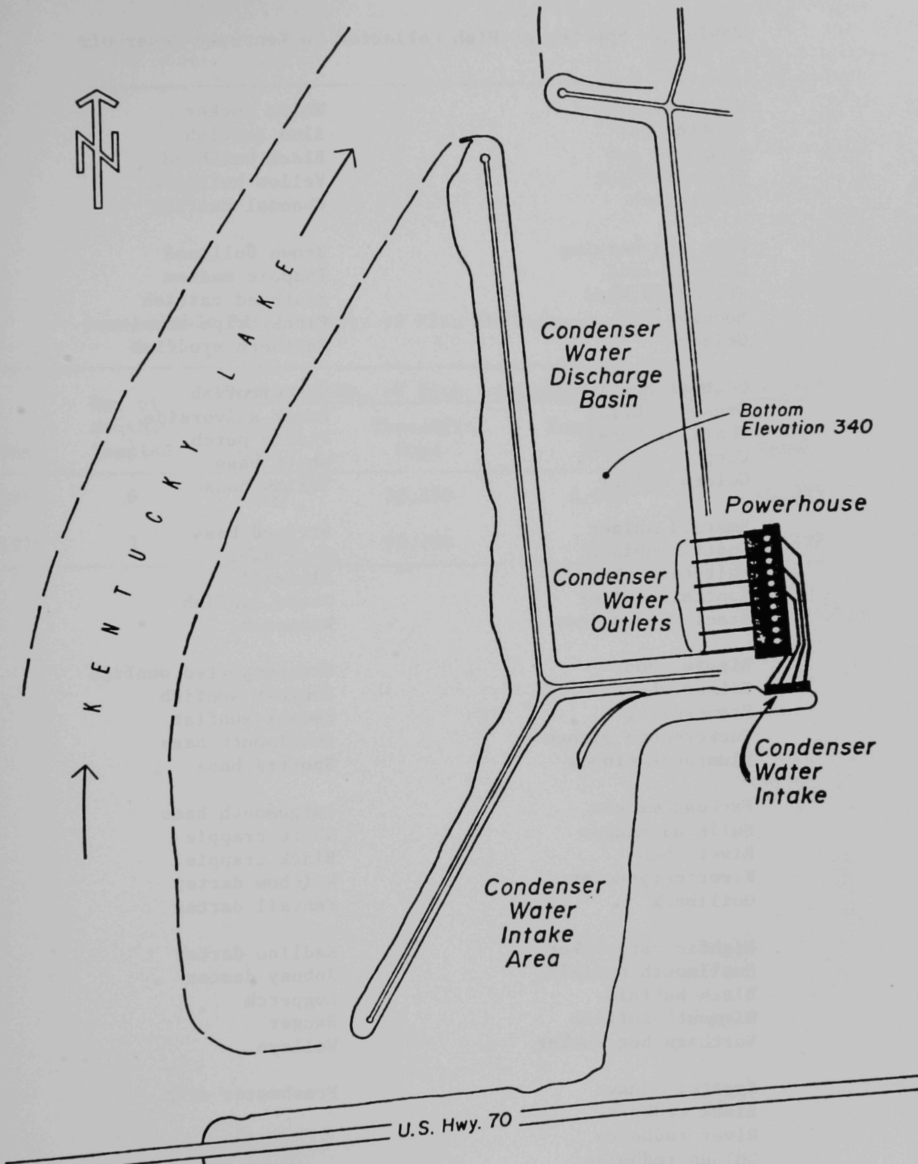


Fig. 1. Intake and Discharge Facilities.

Table I. Species of Fish Collected in Kentucky Reservoir

Bowfin	White sucker
Spotted gar	Blue catfish
Longnose gar	Black bullhead
Shortnose gar	Yellow bullhead
Paddlefish	Channel catfish
Skipjack herring	Brown bullhead
Gizzard shad	Tadpole madtom
Threadfin shad	Flathead catfish
Mooneye	Blackstripe topminnow
Goldeye	Northern studfish
Central mudminnow	Mosquitofish
Grass pickerel	Brook silverside
Chain pickerel	Pirate perch
Carp	White bass
Golden shiner	Yellow bass
Emerald shiner	Striped bass
Spotfin shiner	Rock bass
Whitetail shiner	Bluegill
Spottail shiner	Green sunfish
Steelcolor shiner	Warmouth
Bigeye chub	Orangespotted sunfish
Silver chub	Longear sunfish
Stoneroller	Redear sunfish
Suckermouth minnow	Smallmouth bass
Bluntnose minnow	Spotted bass
Fathead minnow	Largemouth bass
Bullhead minnow	White crappie
River chub	Black crappie
River carpsucker	Rainbow darter
Quillback	Fantail darter
Highfin carpsucker	Redline darter
Smallmouth buffalo	Johnny darter
Black buffalo	Logperch
Bigmouth buffalo	Sauger
Northern hog sucker	Walleye
Spotted sucker	Freshwater drum
Black redhorse	
River redhorse	
Golden redhorse	
Shorthead redhorse	

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled: Gizzard Shad	Threadfin Shad	Freshwater Drum	Total
1974	6	3,657	29,899	4,468	46,053
1975	3	7,779	96,790	7,319	148,202

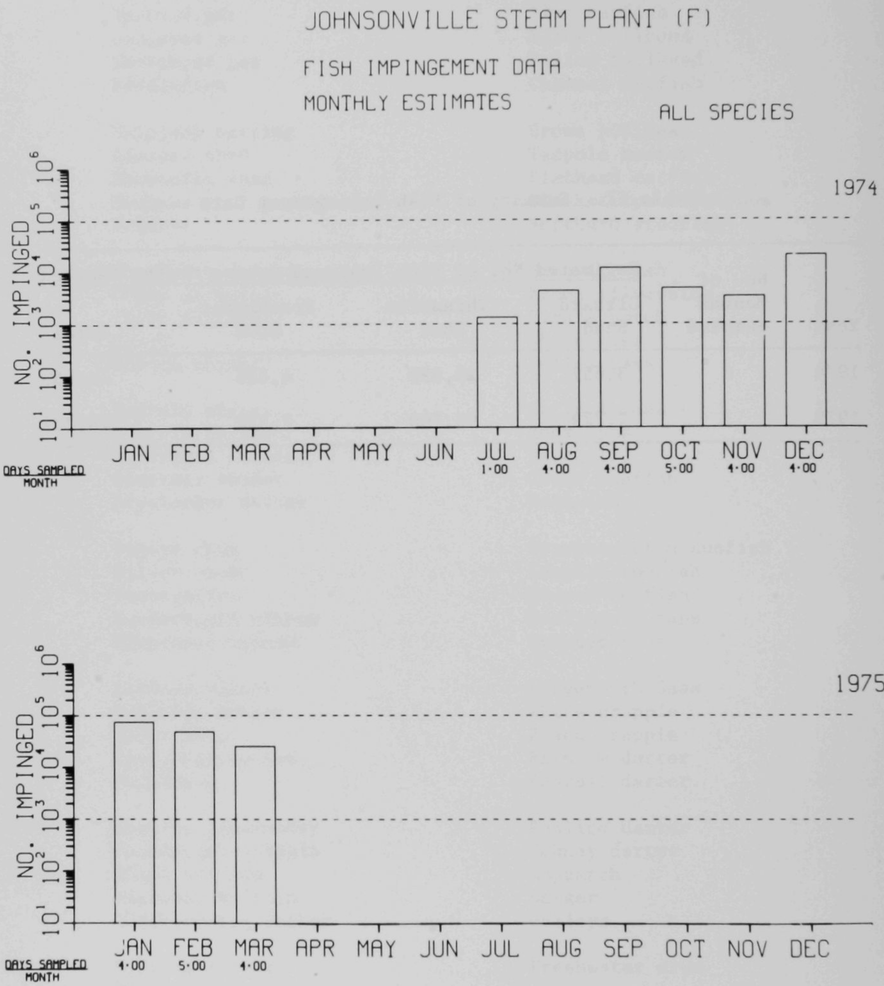
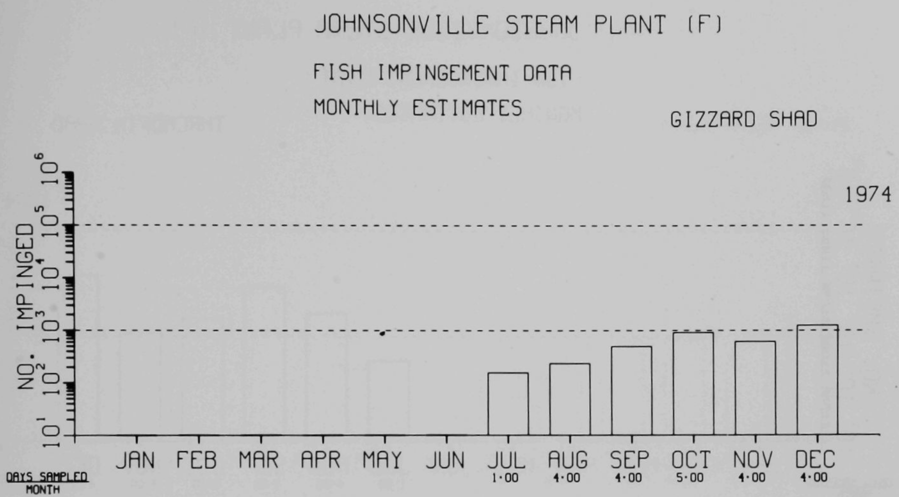


Fig. H1. Impingement Estimates.



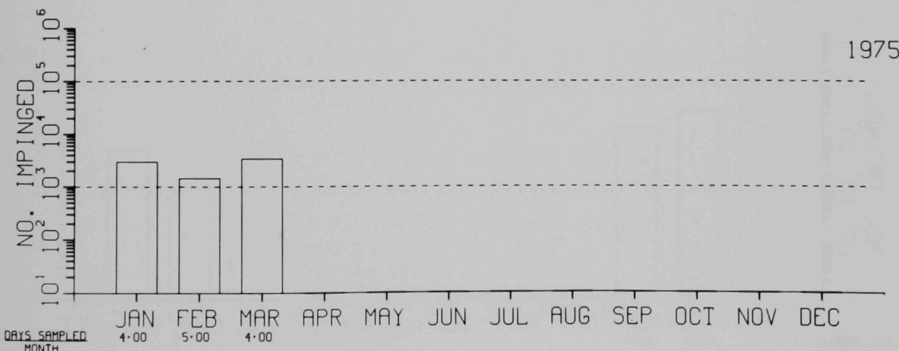


Fig. H2. Impingement Estimates.

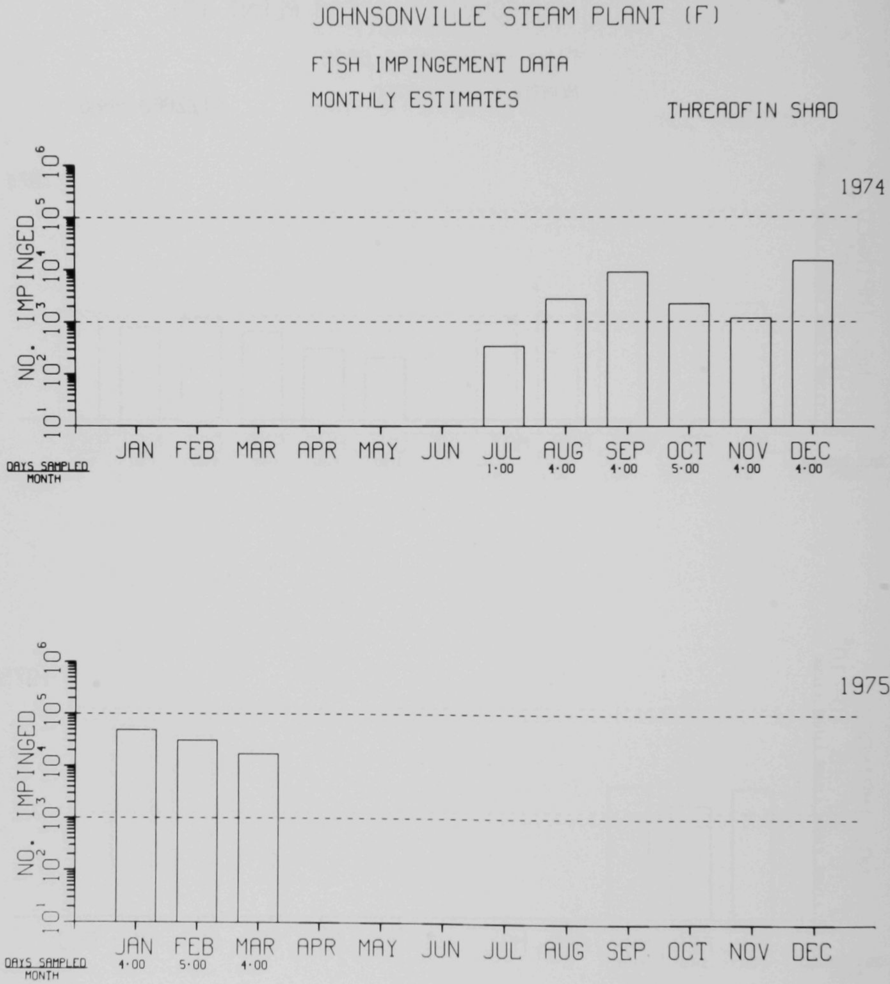


Fig. H3. Impingement Estimates.

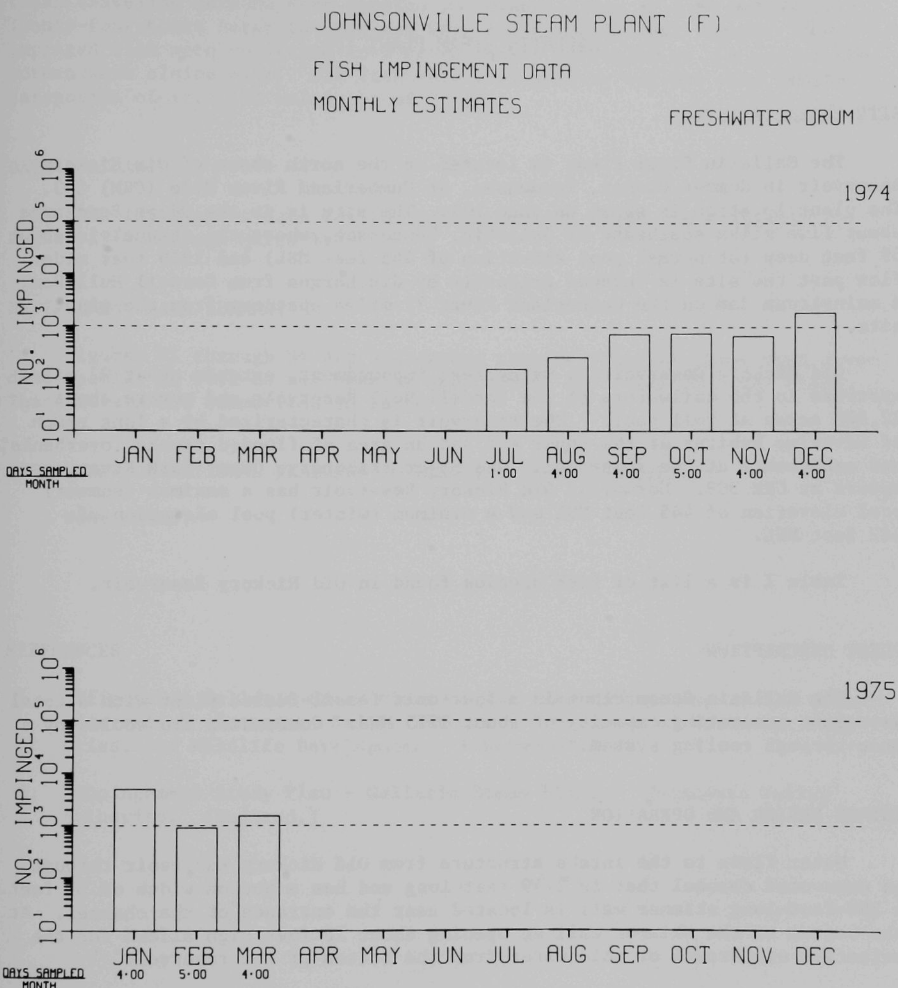


Fig. H4. Impingement Estimates.

GALLATIN STEAM PLANT (F)

SITE CHARACTERISTICS

The Gallatin Steam Plant is located on the north shore of Old Hickory Reservoir in Summer County, Tennessee, at Cumberland River Mile (CRM) 243. The plant location is shown on page 105. The site is in the Odoms Bend area about five miles southeast of Gallatin, Tennessee, where the channel is about 59 feet deep (at normal pool elevation of 445 feet MSL) and 1319 feet wide. Flow past the site is induced primarily by discharges from Cordell Hull Dam, a mainstream dam on the Cumberland River 71 miles upstream from the plant site.

Old Hickory Reservoir, a mainstream impoundment, extends about 97 miles upstream to the tailwaters of the Cordell Hull Reservoir and covers about 22,508 acres at full pool.[1] The reservoir is characterized by a long reach of riverine habitat at the upper end and an area of flooded creeks, overbanks, and embayments at the lower end. One major tributary, Caney Fork River, enters at CRM 309. Normally, Old Hickory Reservoir has a maximum (summer) pool elevation of 445 feet MSL and a minimum (winter) pool elevation of 442 feet MSL.

Table I is a list of fish species found in Old Hickory Reservoir.

PLANT DESCRIPTION

The Gallatin Steam Plant is a four-unit fossil-fueled plant with a total nameplate generating capacity of about 1225 MWe. Condensers are cooled by a once-through cooling system.

INTAKE DESIGN AND OPERATION

Water flows to the intake structure from Old Hickory Reservoir through an excavated channel that is 2749 feet long and has a bottom width of 33 feet. A 390-foot-long skimmer wall is located near the entrance of the channel. At the bottom of the skimmer wall an opening about 18 feet high allows for the selective withdrawal of cold water from the bottom of the reservoir.

The intake structure consists of eight separate pumpwells, each with a circulating-water pump and vertical traveling screen. Condenser cooling-water flow rate is 634,679 gpm.

IMPINGEMENT SAMPLING

A weekly fish-impingement monitoring program began in August 1974 and was scheduled to be conducted through August 1975.[2] Once each week all vertical traveling screens were rotated and washed clean of fish and debris. Twenty-four hours later the screens were again rotated and washed. The impinged fish were collected in a catch basket installed at the end of the screen-wash sluice pipe. All fish were separated by species into length categories of integral multiples of 25 mm.

DATA AVAILABILITY

Fish impingement data for the Gallatin Steam Plant are available for August 1974 through March 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing the three most abundant species as well as all species impinged at the Gallatin Steam Plant. These totals are summarized in Table II.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCES

1. "Effects of Gallatin Steam Plant on the Fish Populations of Old Hickory Reservoir." Tennessee Valley Authority - Division of Forestry, Fisheries, and Wildlife Development. 6 December 1974.

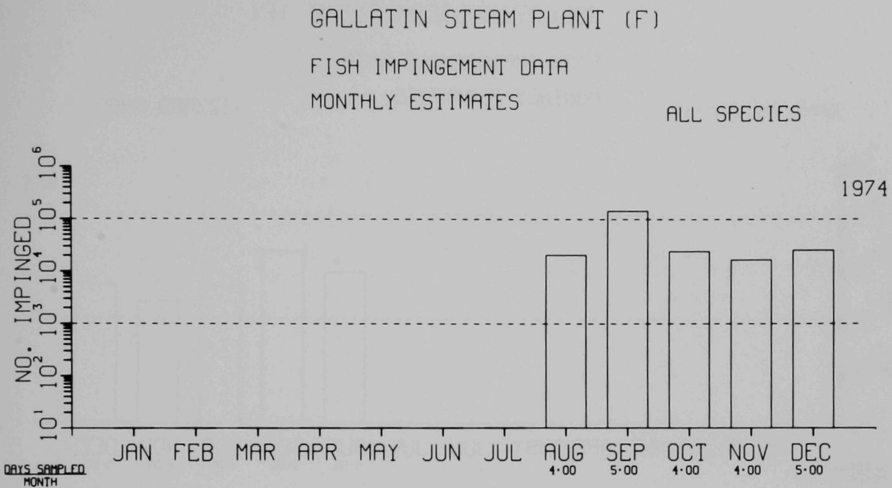
2. "Impingement Study Plan - Gallatin Steam Plant." Tennessee Valley Authority. (Undated.)

Table I. Fish Species Collected in Old Hickory Reservoir

Paddlefish	Black bullhead
Spotted gar	Yellow bullhead
Longnose gar	Brown bullhead
Shortnose gar	Channel catfish
Skipjack herring	Flathead catfish
Gizzard shad	White bass
Threadfin shad	Striped bass
Mooneye	Pumpkinseed
Rainbow trout	Warmouth
Carp	Bluegill
River carpsucker	Longear sunfish
Quillback	Smallmouth bass
Highfin carpsucker	Spotted bass
Smallmouth buffalo	Largemouth bass
Bigmouth buffalo	White crappie
Black buffalo	Black crappie
Spotted sucker	Sauger
River redhorse	Walleye
Golden redhorse	Freshwater drum
Blue catfish	

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled: Gizzard Shad	Threadfin Shad	Freshwater Drum	Total
1974	5	36,780	162,186	16,832	231,280
1975	3	8,260	9,940	4,474	26,214



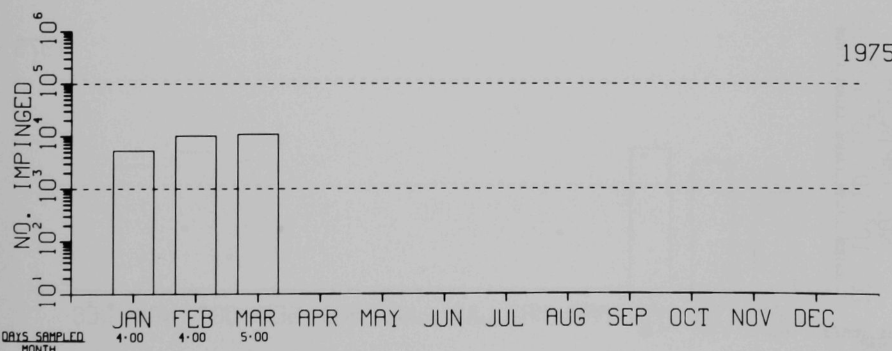


Fig. H1. Impingement Estimates.

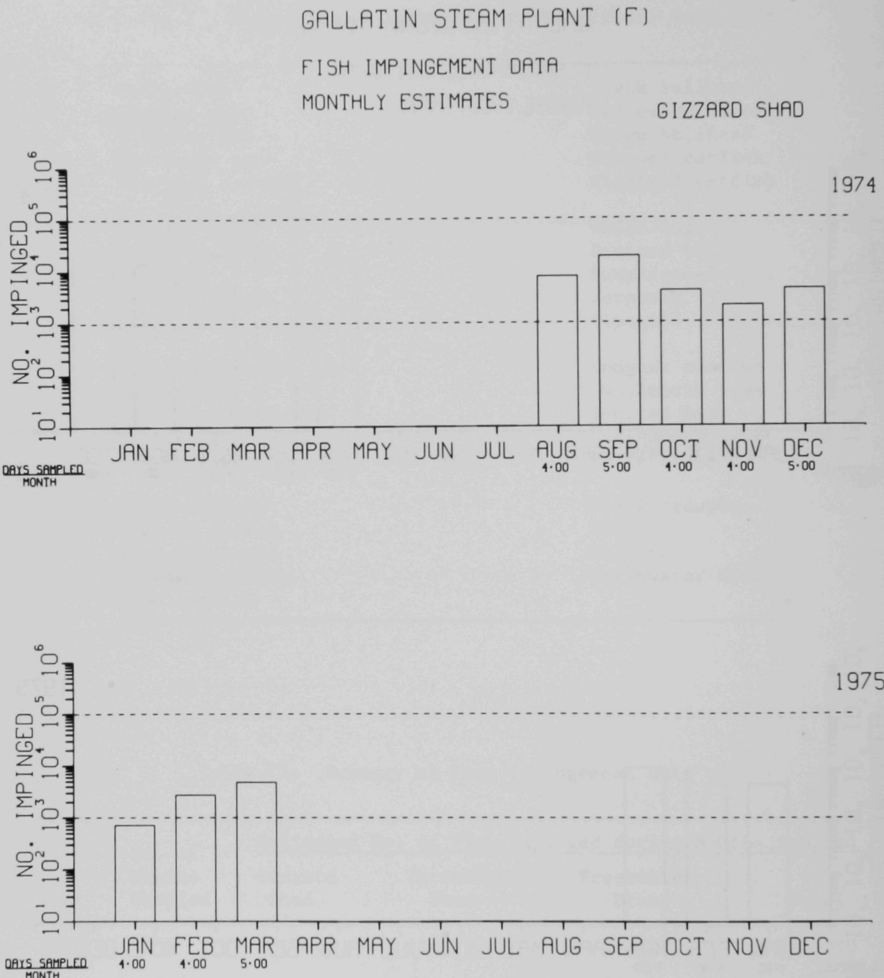


Fig. H2. Impingement Estimates.

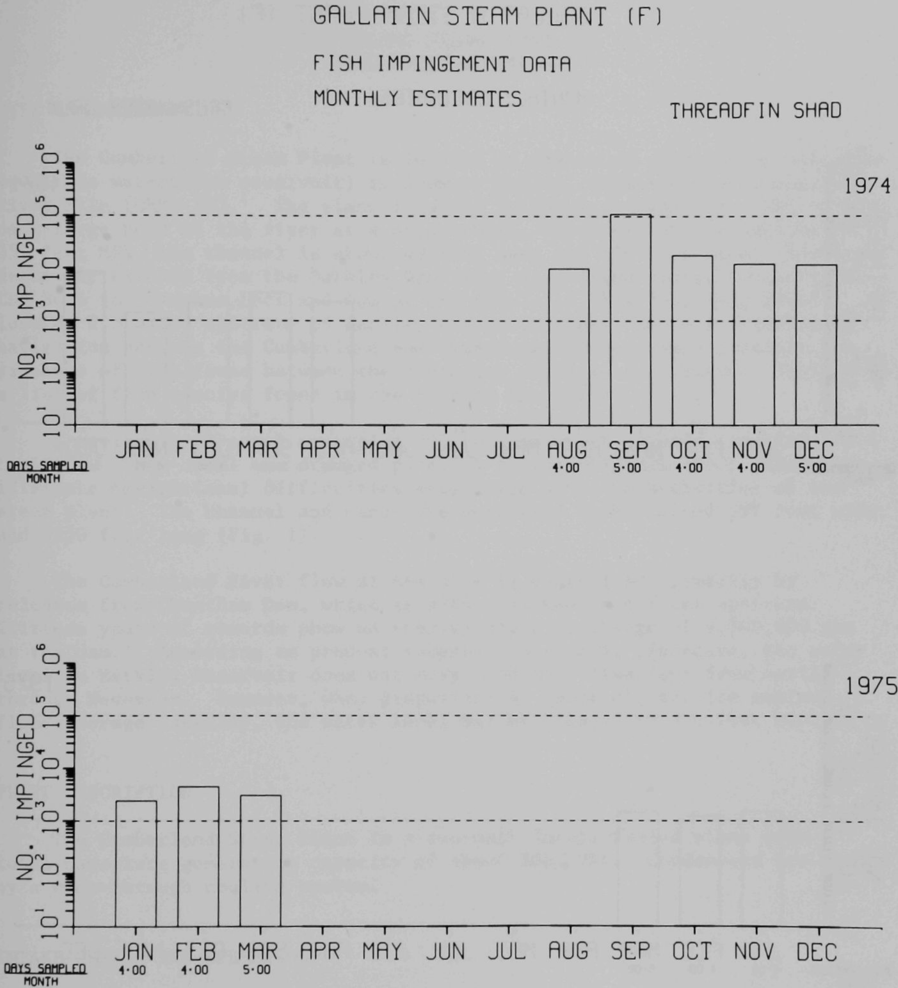


Fig. H3. Impingement Estimates.

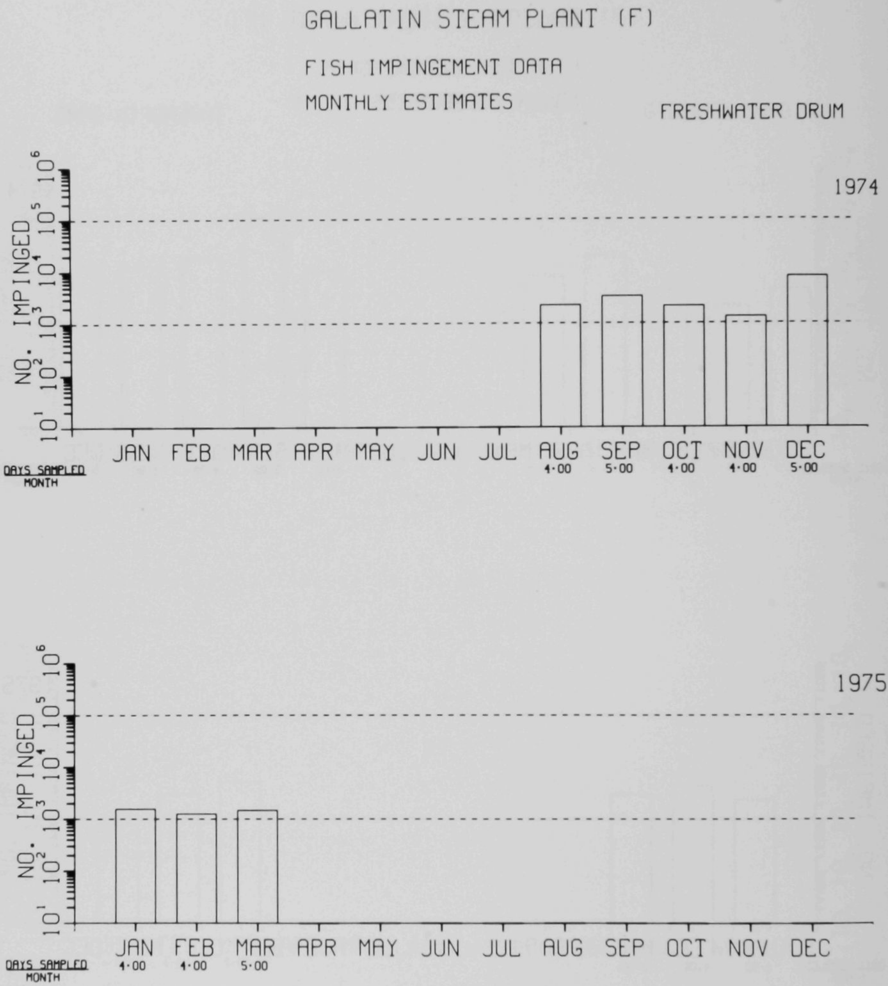


Fig. H4. Impingement Estimates.

CUMBERLAND STEAM PLANT (F)

SITE CHARACTERISTICS

The Cumberland Steam Plant is located on the south shore of Barkley Reservoir (a mainstream reservoir) in Stewart County, Tennessee, at Cumberland River Mile (CRM) 103.[1] The plant location is shown on page 105. The site is on a large bend of the river at a point where, at normal pool elevation of 357 feet MSL, the channel is about 49 feet deep and 600 feet wide. Barkley Reservoir extends from the Barkley Dam site, near Grand River, Kentucky, at CRM 30.6 to Cheatham Lock and Dam at CRM 148.7. A 7874-foot-long canal located 2.5 miles upstream of Barkley Reservoir, constructed to facilitate navigation between the Cumberland and Tennessee Rivers, makes possible the exchange of fish fauna between the drainages of these two rivers. Table I is a list of fish species found in the Barkley Reservoir.

A navigational canal averaging 400 feet in width extends from CRM 102.6 to 104.5. This canal was dredged parallel to the original river channel to eliminate navigational difficulties associated with the activities of the steam plant. The channel and canal are separated by an island 297 feet wide and 5250 feet long (Fig. 1).

The Cumberland River flow at the site is controlled primarily by releases from Cheatham Dam, which is situated about 4.6 miles upstream. Thirteen years of records show an average daily discharge of 9,540,000 gpm at the dam.[2] According to present reservoir operating procedure, the water level in Barkley Reservoir does not vary more than five feet from April through November. However, when preparing the reservoir for its maximum flood-storage capacity, the water level may be dropped to 344 feet MSL.

PLANT DESCRIPTION

The Cumberland Steam Plant is a two-unit fossil-fueled plant with a total nameplate generating capacity of about 2600 MWe. Condensers are cooled by a once-through cooling system.

INTAKE DESIGN AND OPERATION

Circulating water is pumped from Barkley Reservoir at a flow rate of 1,896,311 gpm. The pumping station is located northeast of the powerhouse at the head of an intake channel that is 436 feet long. At the channel inlet, and parallel to the riverbank, a 1112-foot-long skimmer wall with a 6.9-foot opening at the bottom withdraws the cooler water from the bottom of the reservoir. The pumping station consists of eight separate pumpwells, each with a circulating-water pump and two vertical traveling screens.

IMPINGEMENT SAMPLING

Once each week all traveling screens were rotated and washed clean of fish and debris. Twenty-four hours later the screens were rotated and washed again, individually or by unit, and the impinged fish were collected in a catch basket installed at the end of the screen-wash sluice pipe. All screens having water passing through them at the end of the 24-hour period were sampled.[3]

DATA AVAILABILITY

Impingement data for the Cumberland Steam Plant are available for July 1974 through March 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing the total numbers of the three most abundant species as well as all species impinged at the Cumberland Steam Plant. It should be noted that "shad" includes gizzard shad, threadfin shad, and skipjack herring. These totals are summarized in Table II.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCES

1. "The Effects of Cumberland Steam Plant Operation on the Fish Populations of Barkley Reservoir." Tennessee Valley Authority. (Undated.)

2. "Cumberland Steam Plant Water Temperature Surveys." Tennessee Valley Authority. (Undated.)

3. "Impingement Study Plan - Cumberland Steam Plant." Tennessee Valley Authority. (Undated.)

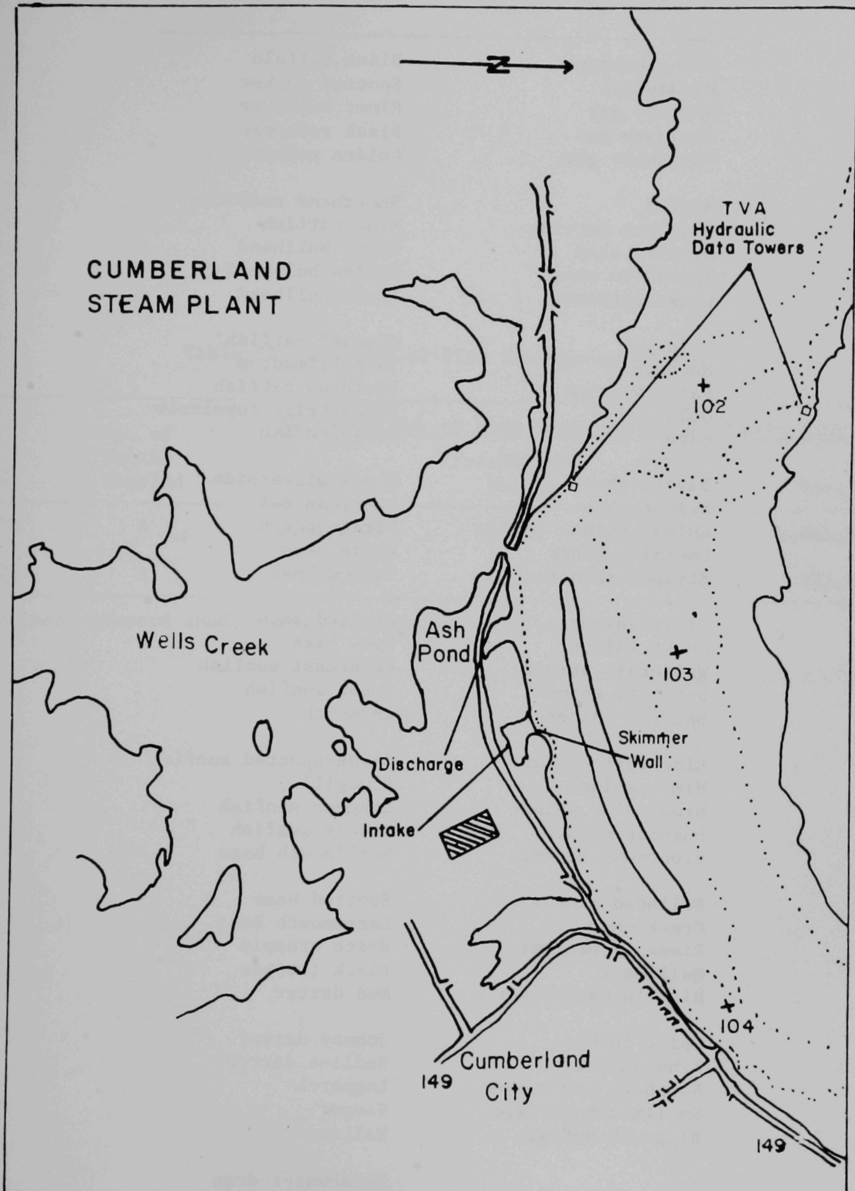


Fig. 1. Barkley Reservoir in the Vicinity of the Plant.

Table I. Fish Species Found near the Plant

Ohio lamprey	Black buffalo
Paddlefish	Spotted sucker
Spotted gar	River redhorse
Longnose gar	Black redhorse
Shortnose gar	Golden redhorse
Bowfin	Shorthead redhorse
Skipjack herring	Blue catfish
Gizzard shad	Black bullhead
Threadfin shad	Yellow bullhead
Grass pickerel	Brown bullhead
Goldeye	Channel catfish
Mooneye	Tadpole madtom
Rainbow trout	Flathead catfish
Goldfish	Blackstripe topminnow
Carp	Mosquitofish
Bigeye chub	Brook silverside
Silver chub	American eel
Golden shiner	Pirate perch
Emerald shiner	White bass
Striped shiner	Yellow bass
River shiner	Striped bass
Ghost shiner	Rock bass
Whitetail shiner	Redbreast sunfish
Spottail shiner	Green sunfish
Spotfin shiner	Warmouth
Blacktail shiner	Orangespotted sunfish
Mimic shiner	Bluegill
Steelcolor shiner	Longear sunfish
Pugnose minnow	Redear sunfish
Bluntnose minnow	Smallmouth bass
Bullhead minnow	Spotted bass
Creek chub	Largemouth bass
River carpsucker	White crappie
Quillback	Black crappie
Highfin carpsucker	Mud darter
White sucker	Johnny darter
Blue sucker	Redline darter
Northern hog sucker	Logperch
Smallmouth buffalo	Sauger
Bigmouth buffalo	Walleye
	Freshwater drum
	Banded sculpin

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Shad[a]	Freshwater Drum	Silver Chub	Total
1974	6	2,644,315	46,826	1,592	2,945,575
1975	3	211,822	5,778	8,070	227,844

[a]Includes gizzard shad, threadfin shad, and skipjack herring.

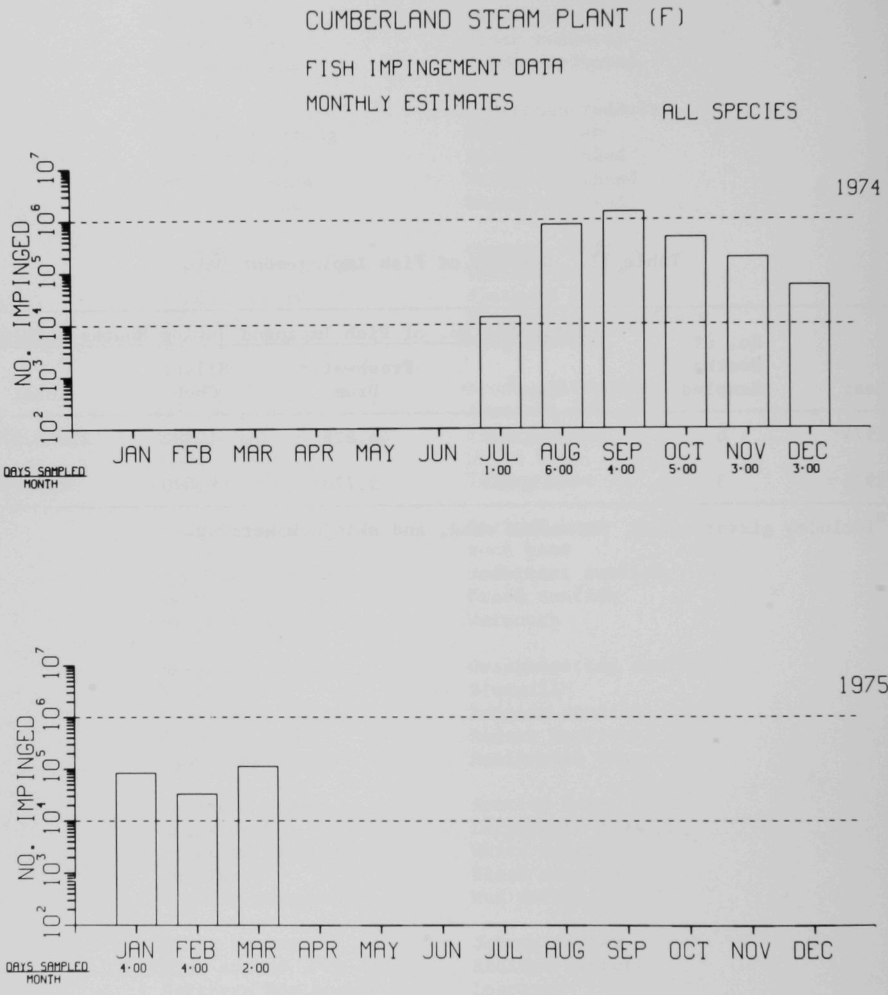


Fig. H1. Impingement Estimates.

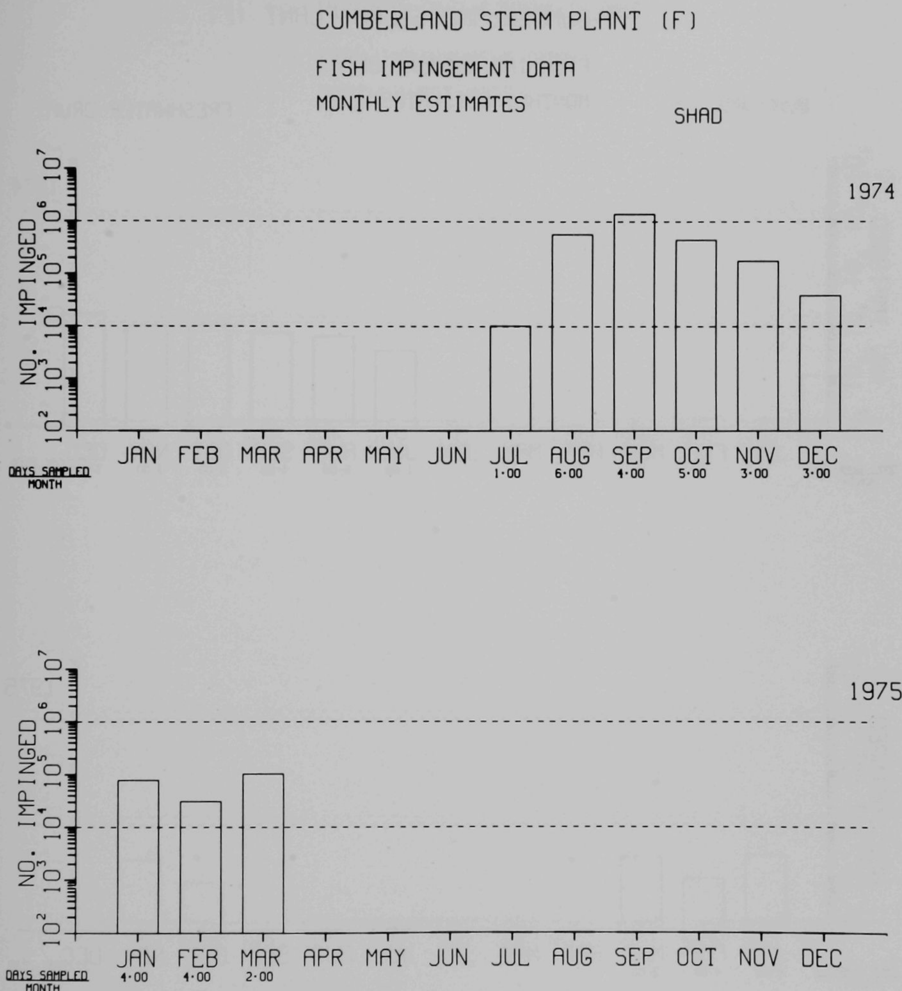


Fig. H2. Impingement Estimates.

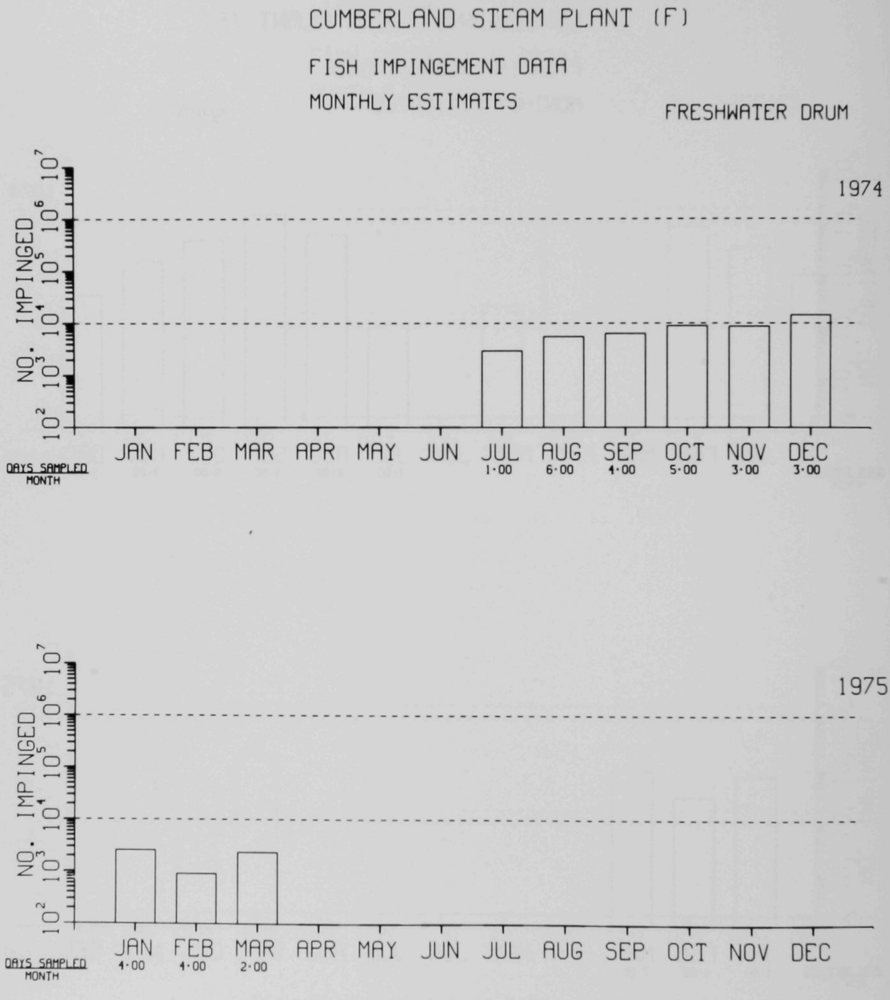


Fig. H3. Impingement Estimates.

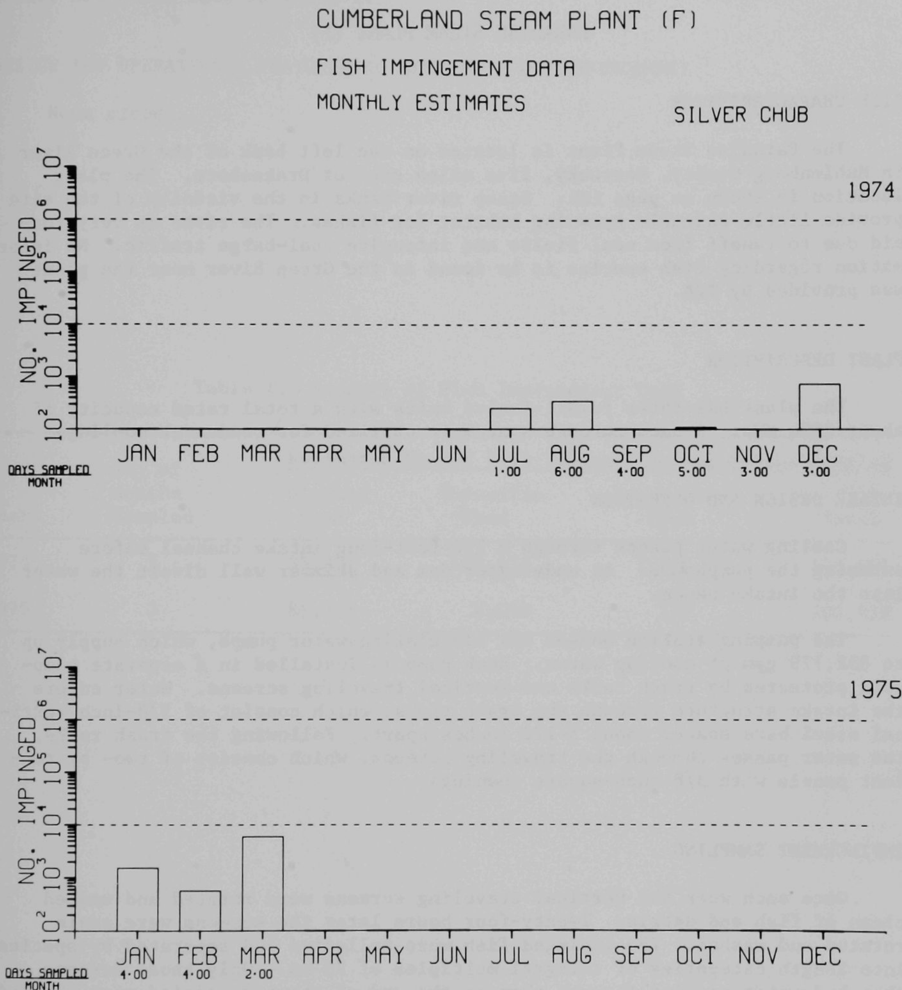


Fig. H4. Impingement Estimates.

PARADISE STEAM PLANT (F)

SITE CHARACTERISTICS

The Paradise Steam Plant is located on the left bank of the Green River in Muhlenberg County, Kentucky, five miles east of Drakesboro. The plant location is shown on page 105. Steep river banks in the vicinity of the site provide little suitable spawning habitat for fishes. The river is very turbid due to runoff from coal fields and intensive coal-barge traffic. No information regarding fish species to be found in the Green River near the plant was provided by TVA.

PLANT DESCRIPTION

The plant has three fossil-fueled units with a total rated capacity of about 2558 MWe. A once-through system is utilized for condenser cooling.

INTAKE DESIGN AND OPERATION

Cooling water passes through a 270-foot-long intake channel before entering the pumphouse. An underwater dam and skimmer wall divert the water into the intake basin.

The pumping station houses six circulating-water pumps, which supply up to 852,779 gpm of cooling water. Each pump is installed in a separate pumpwell protected by trash racks and vertical traveling screens. Water enters the intake structure through the trash racks, which consist of 5/8-inch vertical steel bars spaced about 3-1/2 inches apart. Following the trash racks, the water passes through the traveling screens, which consist of two- by ten-foot panels with 3/8-inch-square openings.

IMPINGEMENT SAMPLING

Once each week the vertical traveling screens were rotated and washed clean of fish and debris. Twenty-four hours later the screens were again rotated and washed. The impinged fish were collected and separated by species into length categories of integral multiples of 25 mm. Only those screens that had water passing through them at the end of the test period were sampled.

DATA AVAILABILITY

Fish impingement data for the Paradise Steam Plant are available for August 1974 through March 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing the three most abundant species as well as all species impinged at the Paradise Steam Plant. These totals are summarized in Table I.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

Table I. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Gizzard Shad	Threadfin Shad	Freshwater Drum	Total
1974	5	35,921	104,470	2,468	143,461
1975	3	86,528	8,008	137	103,958

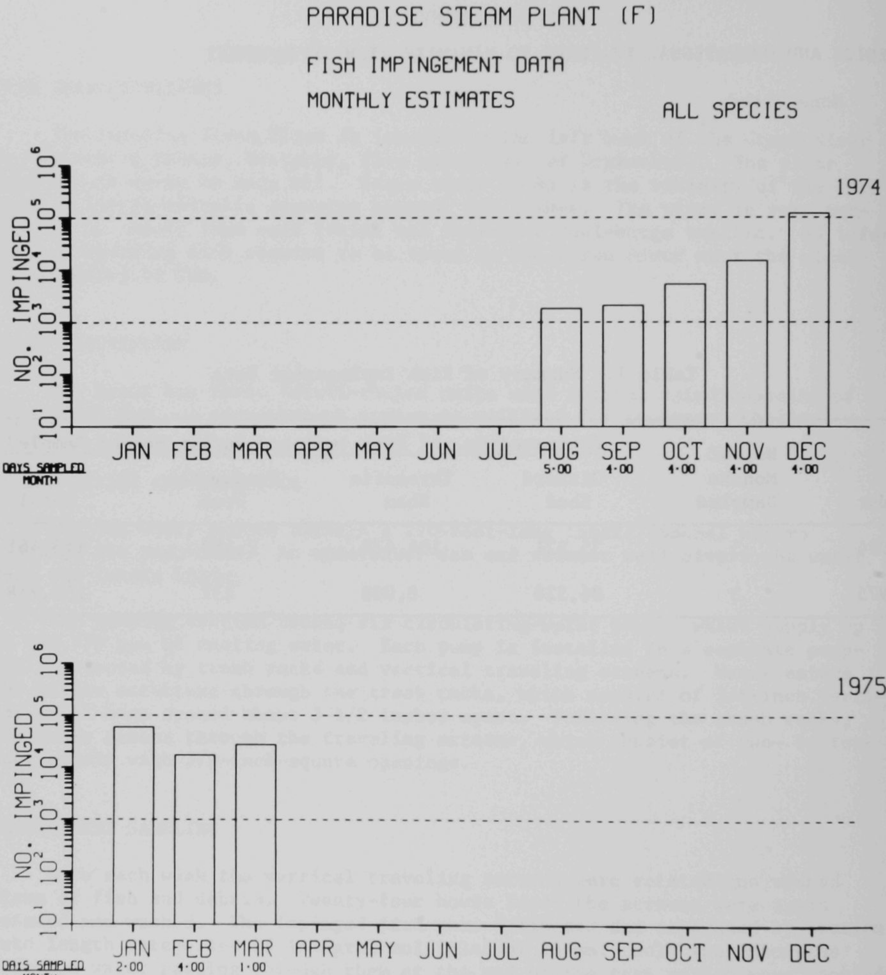


Fig. H1. Impingement Estimates.

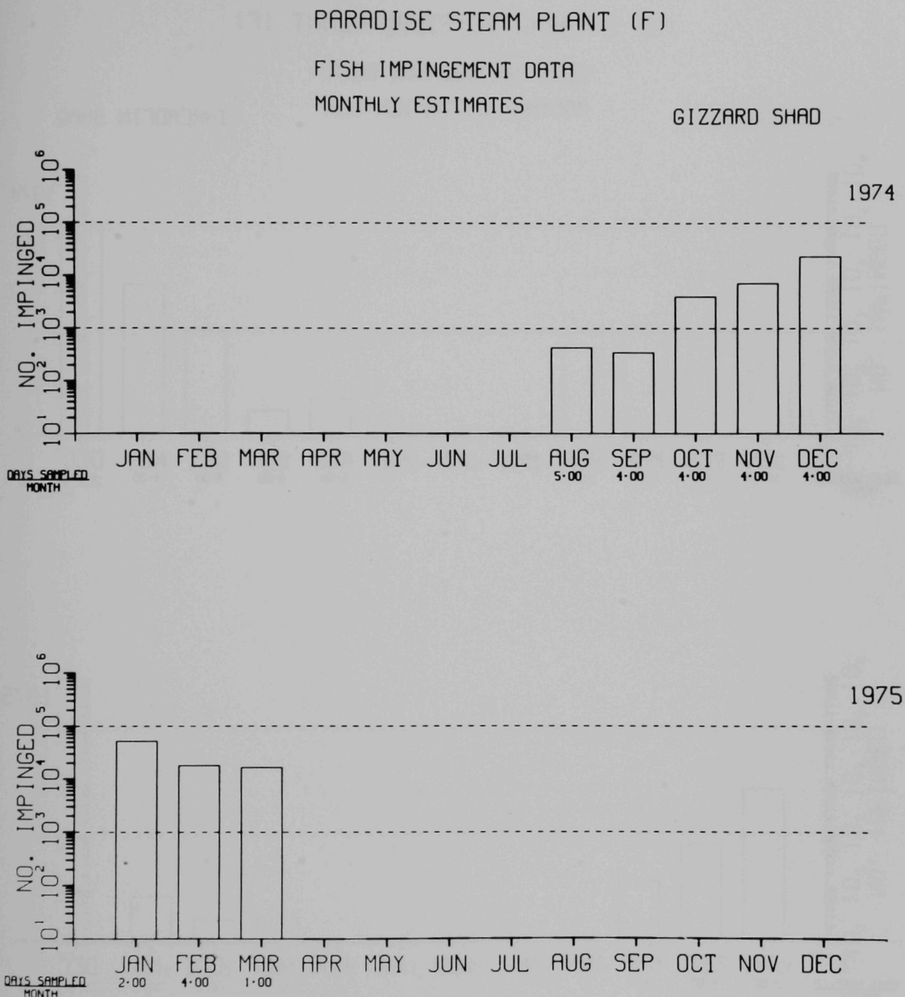


Fig. H2. Impingement Estimates.

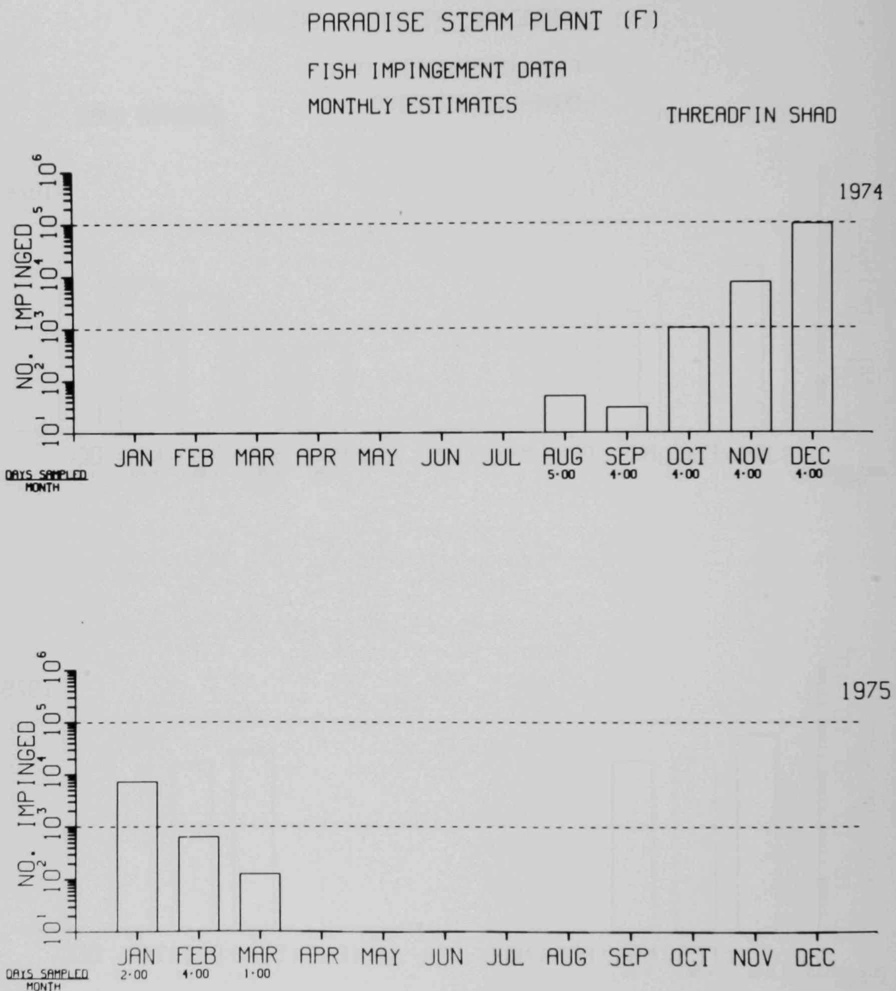


Fig. H3. Impingement Estimates.

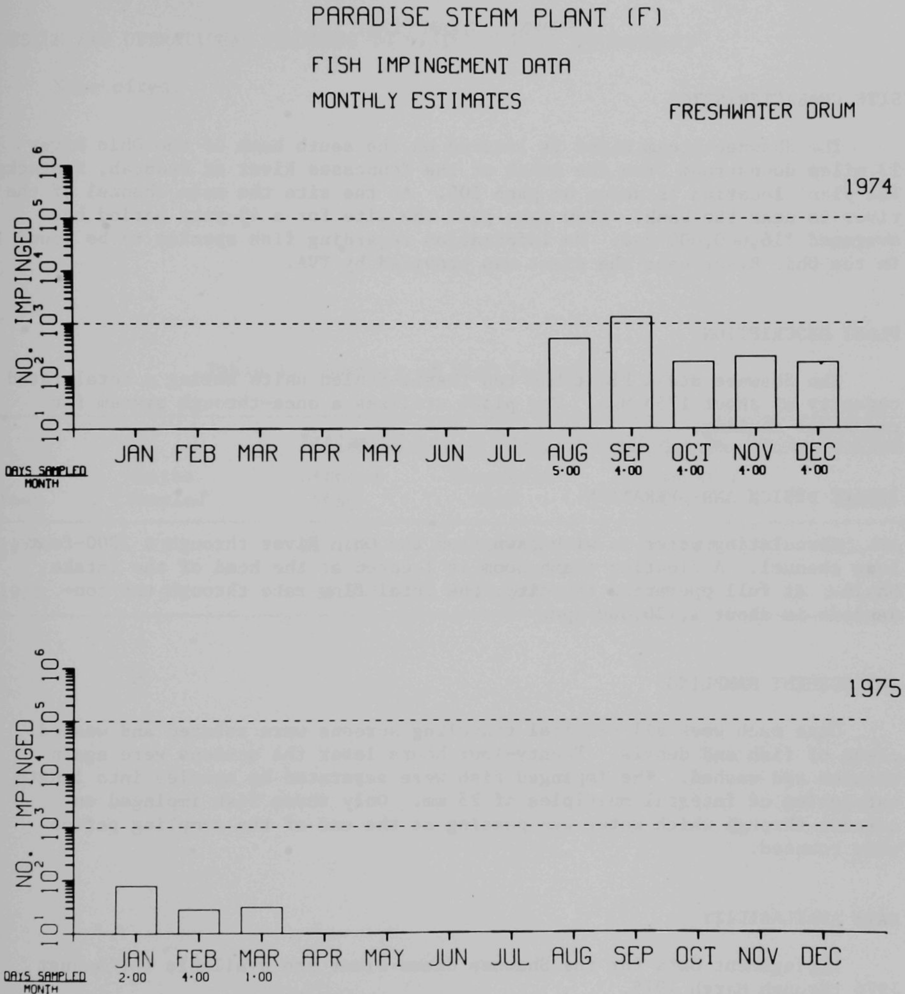


Fig. H4. Impingement Estimates.

SHAWNEE STEAM PLANT (F)

SITE CHARACTERISTICS

The Shawnee Steam Plant is located on the south bank of the Ohio River 13 miles downstream from the mouth of the Tennessee River at Paducah, Kentucky. The plant location is shown on page 105. At the site the main channel of the river is near the bank. Flow rate past the site for a 45-year period has averaged 116,000,000 gpm. No information regarding fish species to be found in the Ohio River near the plant was provided by TVA.

PLANT DESCRIPTION

The Shawnee Steam Plant has ten fossil-fueled units having a total rated capacity of about 1750 MWe. The plant utilizes a once-through system for condenser cooling.

INTAKE DESIGN AND OPERATION

Circulating water is withdrawn from the Ohio River through a 2000-foot-long channel. A floating trash boom is located at the head of the intake basin. At full operating capacity, the total flow rate through the condensers is about 1,120,000 gpm.

IMPINGEMENT SAMPLING

Once each week all vertical traveling screens were rotated and washed clean of fish and debris. Twenty-four hours later the screens were again rotated and washed. The impinged fish were separated by species into length categories of integral multiples of 25 mm. Only those fish impinged on screens through which water was passing at the end of the sampling period were counted.

DATA AVAILABILITY

Impingement data for the Shawnee Steam Plant are available for August 1974 through March 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing the total numbers of the three most abundant species as well as all species impinged at the Shawnee Steam Plant. These totals are summarized in Table I.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

Table I. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Gizzard Shad	Threadfin Shad	Freshwater Drum	Total
1974	5	250,363	141,798	185,828	605,434
1975	3	25,941	216,365	73,872	347,899

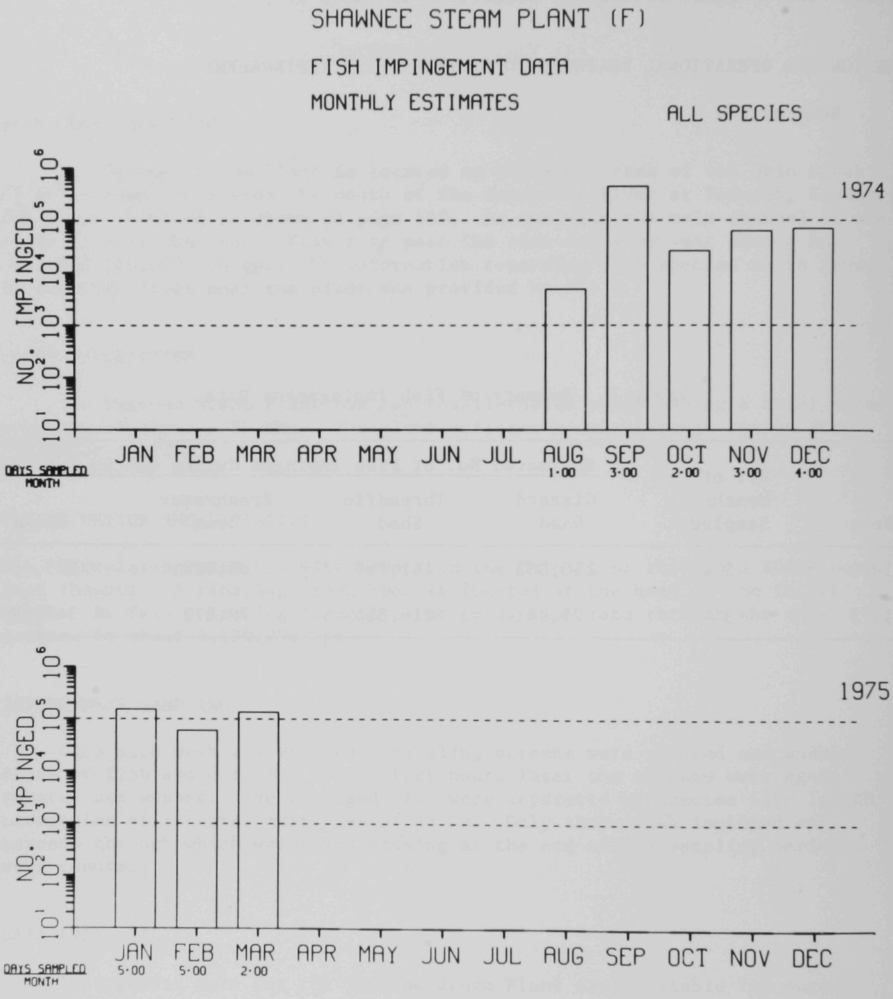


Fig. H1. Impingement Estimates.

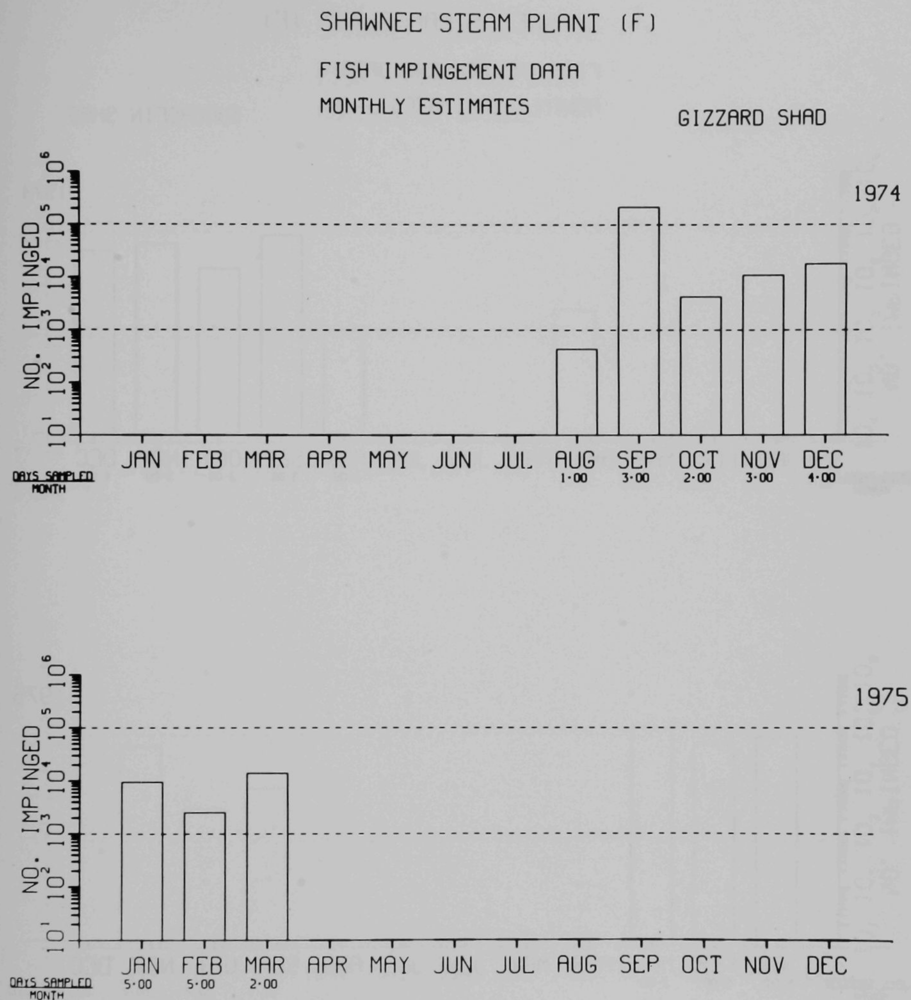


Fig. H2. Impingement Estimates.

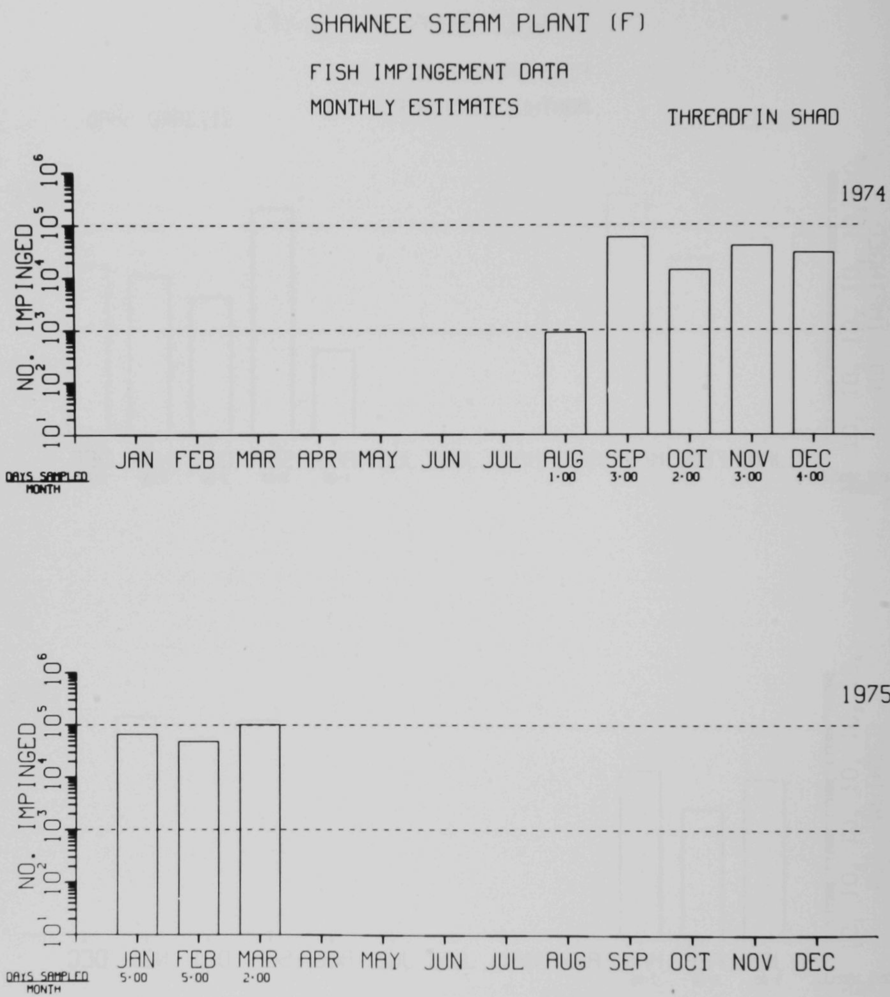


Fig. H3. Impingement Estimates.

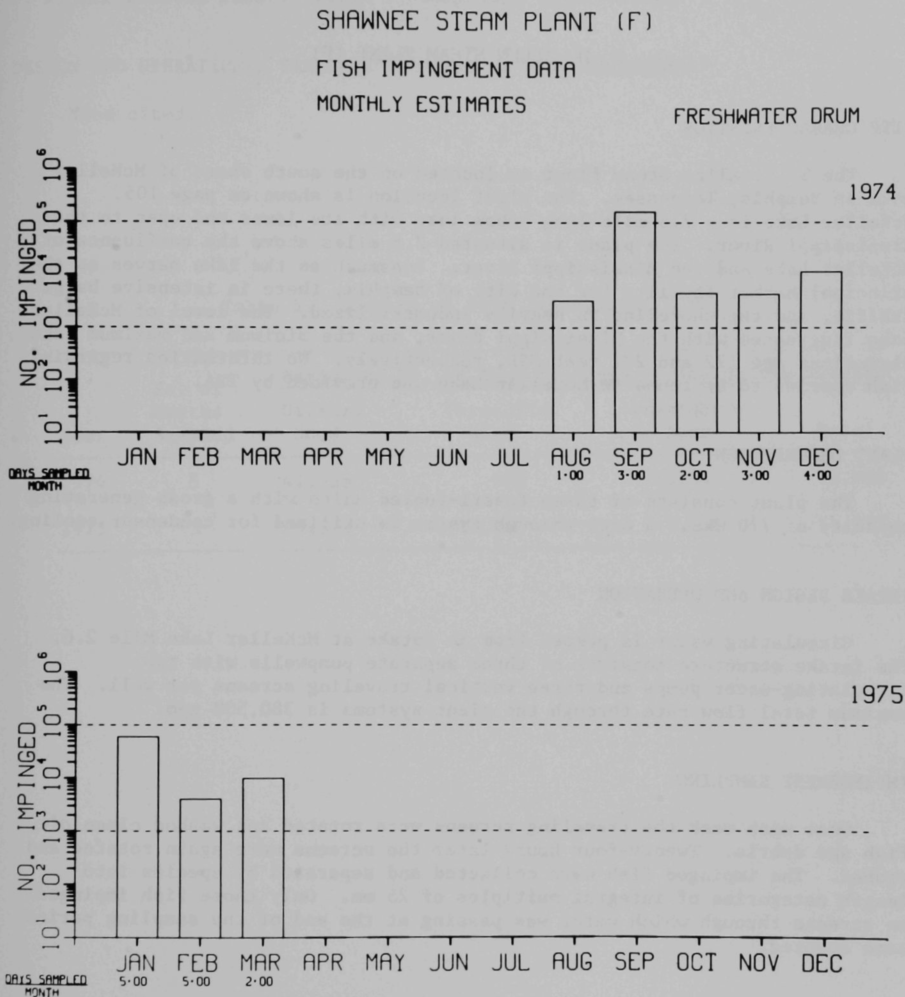


Fig. H4. Impingement Estimates.

T. H. ALLEN STEAM PLANT (F)

SITE CHARACTERISTICS

The T. H. Allen Steam Plant is located on the south shore of McKellar Lake in Memphis, Tennessee. The plant location is shown on page 105. McKellar Lake is a 7.8-mile-long oxbow lake with its lower end open to the Mississippi River. The plant is situated 2.6 miles above the confluence of McKellar Lake and the Mississippi River. Inasmuch as the lake serves as the principal harbor facility for the City of Memphis, there is intensive barge traffic, and the shoreline is heavily industrialized. The level of McKellar Lake fluctuates with the Mississippi River, and the minimum and maximum lake elevations are 172 and 231 feet MSL, respectively. No information regarding fish species to be found in McKellar Lake was provided by TVA.

PLANT DESCRIPTION

The plant consists of three fossil-fueled units with a gross generating capacity of 770 MWe. A once-through system is utilized for condenser cooling.

INTAKE DESIGN AND OPERATION

Circulating water is pumped from an intake at McKellar Lake Mile 2.6. The intake structure consists of three separate pumpwells with two circulating-water pumps and three vertical traveling screens per well. The maximum total flow rate through the plant systems is 380,500 gpm.

IMPINGEMENT SAMPLING

Once each week the traveling screens were rotated and washed clean of fish and debris. Twenty-four hours later the screens were again rotated and washed. The impinged fish were collected and separated by species into length categories of integral multiples of 25 mm. Only those fish impinged on screens through which water was passing at the end of the sampling period were counted.

DATA AVAILABILITY

Fish impingement data for the T. H. Allen Steam Plant are available for August 1974 through March 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing the total numbers of the three most abundant species as well as all species impinged at the T. H. Allen Steam Plant. Table I summarizes these totals.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

Table I. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Gizzard Shad	Threadfin Shad	Freshwater Drum	Total
1974	5	41,456	909	11,631	59,489
1975	3	69,322	13,000	7,315	95,272

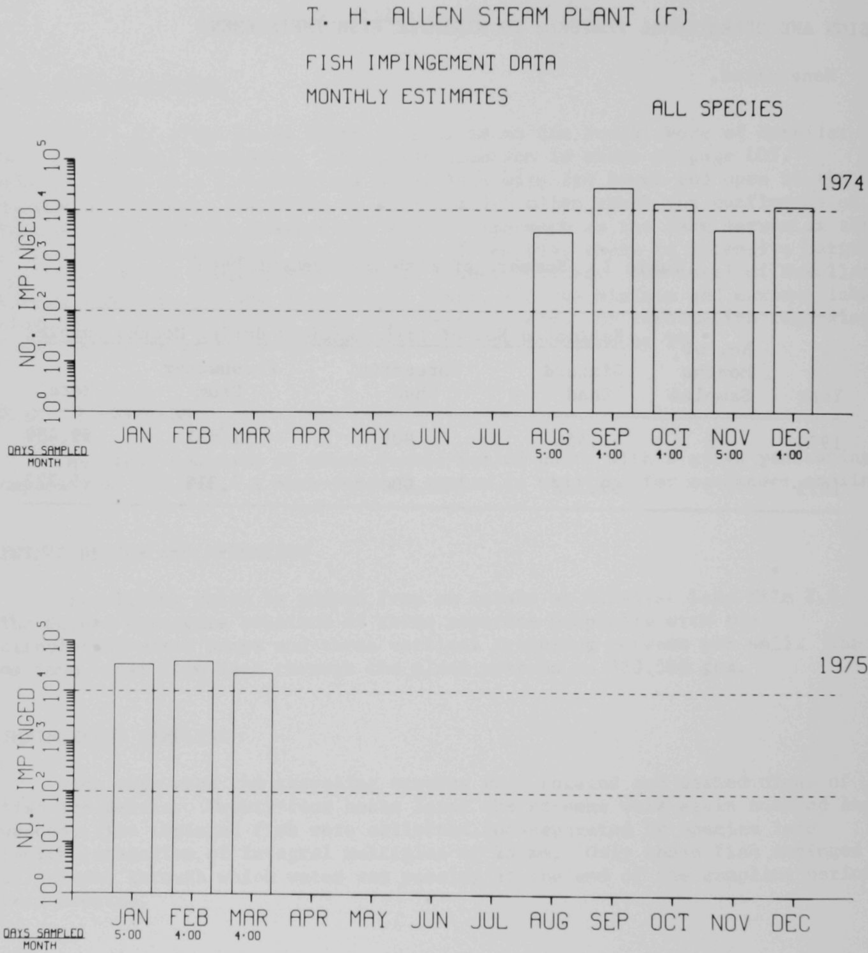


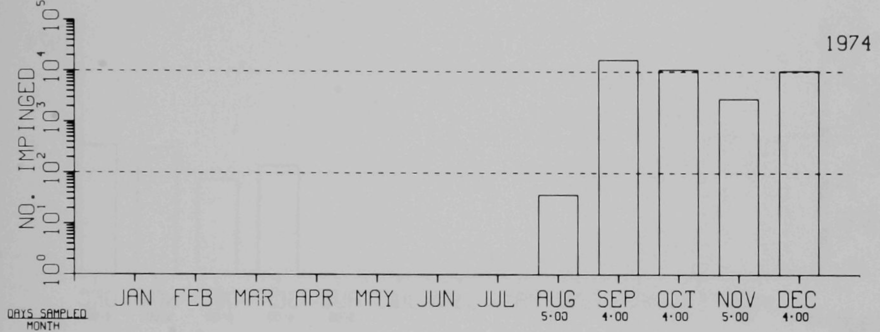
Fig. H1. Impingement Estimates.

T. H. ALLEN STEAM PLANT (F)

FISH IMPINGEMENT DATA

MONTHLY ESTIMATES

GIZZARD SHAD



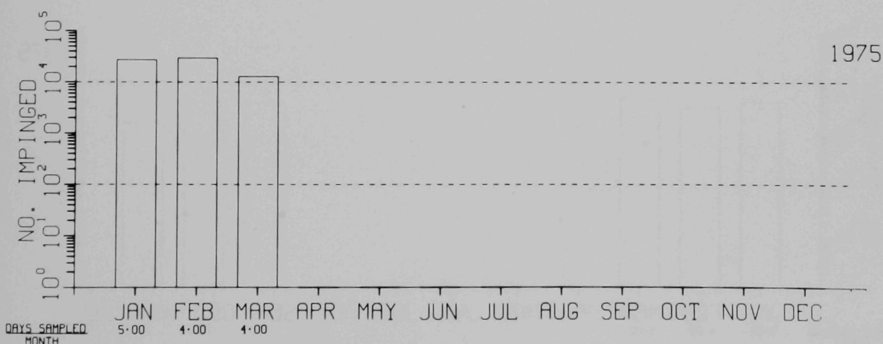


Fig. H2. Impingement Estimates.

T. H. ALLEN STEAM PLANT (F)

FISH IMPINGEMENT DATA

MONTHLY ESTIMATES

THREADFIN SHAD

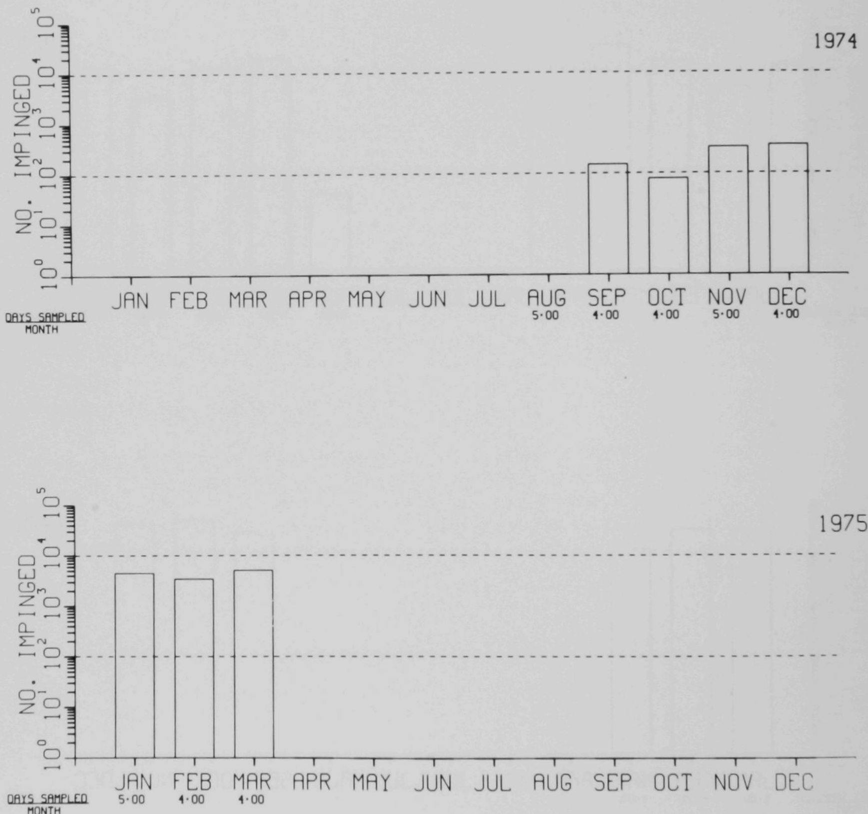


Fig. H3. Impingement Estimates.

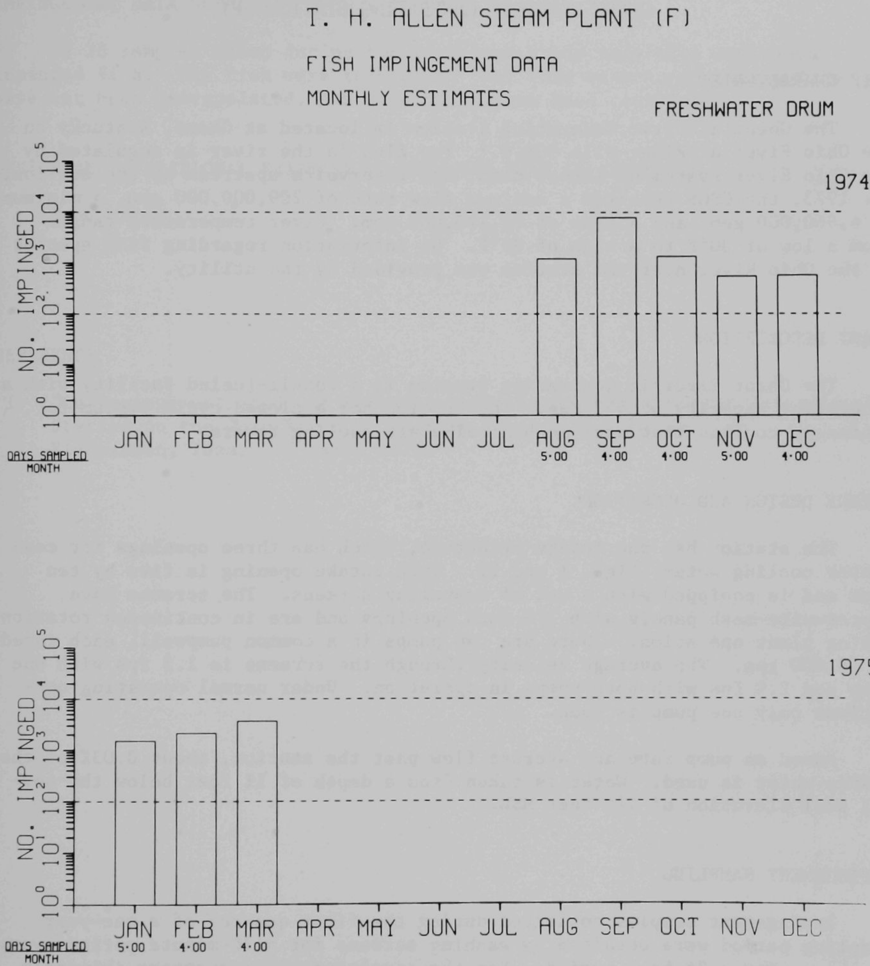


Fig. H4. Impingement Estimates.

GHENT ELECTRIC GENERATING STATION (F)

SITE CHARACTERISTICS

The Ghent Electric Generating Station is located at Ghent, Kentucky on the Ohio River at River Mile 536.0.[1] The flow in the river is regulated by the Ohio River system of locks, dams, and reservoirs upstream of the station. For 1973, the USGS reported a maximum flow rate of 209,000,000 gpm, a minimum of 6,960,000 gpm, and a mean of 62,120,000 gpm. River temperature ranges from a low of 30°F to a high of 85°F. No information regarding fish species in the Ohio River near the station was provided by the utility.

PLANT DESCRIPTION

The Ghent Electric Generating Station is a fossil-fueled facility with a generating capacity of 557 MWe. The station has a closed-cycle system for condenser cooling that uses mechanical-draft cooling towers.

INTAKE DESIGN AND OPERATION

The station has one intake structure, which has three openings for condenser cooling water (Figs. 1 and 2). Each intake opening is five by ten feet and is equipped with a set of traveling screens. The screens have copper-wire-mesh panels with 3/8-inch openings and are in continuous rotation during plant operation. There are two pumps in a common pumpwell, each rated at 18,000 gpm. The average velocity through the screens is 1.5 fps with one pump and 2.9 fps with both pumps in operation. Under normal operating conditions only one pump is used.

Based on pump rate and average flow past the station, about 0.03% of the source water is used. Water is taken from a depth of 11 feet below the normal pool elevation of 420 feet MSL.

IMPINGEMENT SAMPLING

Impingement samples collected during the first quarter of a one-year sampling period were obtained by washing screens for a 20-minute period every six hours for a 24-hour period. For the remaining three quarters, biweekly samples consisted of one continuous 24-hour washing that was checked every six hours.

DATA AVAILABILITY

Impingement data for the Ghent Electric Generation Station are available for November 1974 through November 1975.

IMPINGEMENT DATA SUMMARY

Of 28 samples taken during the year-long study only five contained impinged fish. Six fish were recovered. For this reason, monthly totals have not been extrapolated, nor have histograms been constructed.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCE

1. "An Impingement Study at Kentucky Utilities' Ghent Electric Generating Station on the Ohio River." Summary Report, Geo-Marine, Inc., Richardson, Texas. 2 March 1976.

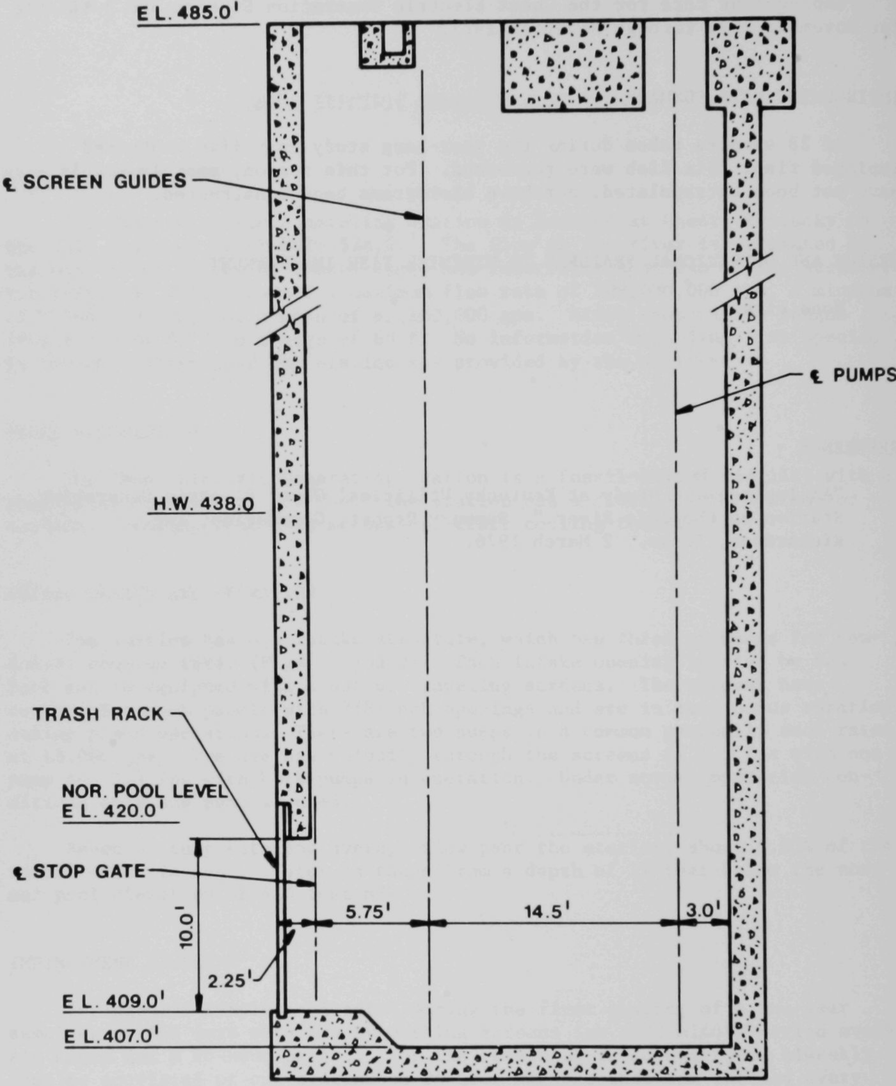


Fig. 1. Side View of the Intake Structure.

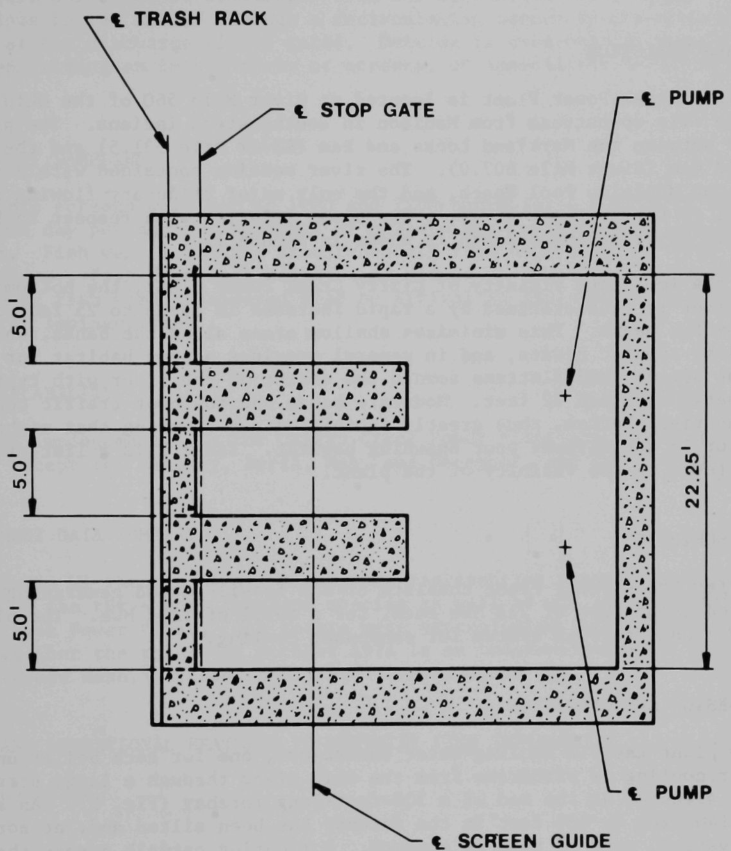


Fig. 2. Top View of the Intake Structure.

CLIFTY CREEK POWER PLANT (F)

SITE CHARACTERISTICS

Clifty Creek Power Plant is located at River Mile 560 of the Ohio River, about one mile downstream from Madison in southeastern Indiana. The plant is situated between the Markland Locks and Dam (River Mile 531.5) and the McAlpine Locks and Dam (River Mile 607.0). The river section contained within these dams is the McAlpine Pool Reach, and the only major tributary flowing into this pool is the Kentucky River.[1] The plant location with respect to the Upper Ohio River Drainage Basin is shown in Figure 1.

In the immediate vicinity of Clifty Creek Power Plant, the bottom profile of the river is characterized by a rapid increase in depth to 25 feet at 25 feet from the banks. This minimizes shallow areas along the banks, which are utilized by aquatic plants, and in general provides a poor habitat for spawning. The bottom then flattens toward the center of the river with typical depths between 28 and 32 feet. Moderate barge and tow-boat traffic constantly stirs the river bottom, thus greatly inhibiting any spawning that might otherwise occur in the already poor spawning habitat. Table I is a list of fish species found in the vicinity of the plant.

PLANT DESCRIPTION

Clifty Creek Power Plant consists of six fossil-fueled generating units with rated capacities of 214 MWe each, for a total of 1284 MWe. The plant utilizes a once-through system for condenser cooling.

INTAKE DESIGN AND OPERATION

The plant has six cooling-water condensers, one for each boiler unit. Water for cooling is withdrawn from the Ohio River through a large screenhouse, which is situated at the end of a 300-foot-long forebay (Fig. 2). An area roughly 140 feet by 200 feet in the forebay has been silted and, at normal pool elevation, part of this is exposed. A floating catwalk across the mouth of the forebay keeps out floating trash.

The screenhouse is divided into six sections, one per unit, with a dividing wall between each section. Each section contains three intake gates, three trash racks, three traveling screens, and two circulating-water pumps. Once water is in the screenhouse, it flows through the trash racks, composed of three-inch by 3/4-inch vertical steel bars spaced about 2-3/4 inches apart. The water then passes through traveling screens, which have 3/8-inch-square openings. Typical velocities are 1.64 fps through the intake gates, 0.93 fps through the trash racks, and 1.62 fps through the traveling screens. Following the screens, water flows through two 66-inch elbows to two 83,000-gpm centrifugal, circulating-water pumps. The total flow rate for all units is 996,000 gpm.

If ice accumulates in front of the trash racks during cold weather, some of the warm water can be discharged from the condensers for deicing. This water flows to the intake through a recirculating tunnel from a concrete chamber at the discharge sluice gates. Deicing is used only if ice is actually seen forming on intake racks or screens, or immediately in front of the intake.

IMPINGEMENT SAMPLING

Sample screens were set at 1000 and 2200 hours for a period of eight hours, one day per month. Movement of baskets was controlled by a plant employee. Fish were collected simultaneously from each unit by three two-member teams. Fish from each basket were placed in individually labeled bags. Decomposing fish were considered dead on arrival at the screens and were not treated as impinged fish.

DATA AVAILABILITY

Fish impingement data for Clifty Creek Power Plant are available for all of 1974 except for January, April, May, and December, and for January 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing extrapolated total numbers of the three most abundant species as well as all species impinged at Clifty Creek Power Plant. The totals were extraploated from monthly average estimates, but the total for October 1974 is an underestimate due to a premature screen wash.[2] These totals are summarized in Table II.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCES

1. John H. Balletto. "Clifty Creek Power Plant Fish Impingement and Entrainment for Indiana-Kentucky Electric Corporation." American Electric Power Service Corporation. 1 April 1976.

2. "Fish Entrapment on Cooling Water Intake Screens at Clifty Creek Power Plant." Aquatic Control, Seymour, Indiana. 1 January 1975.

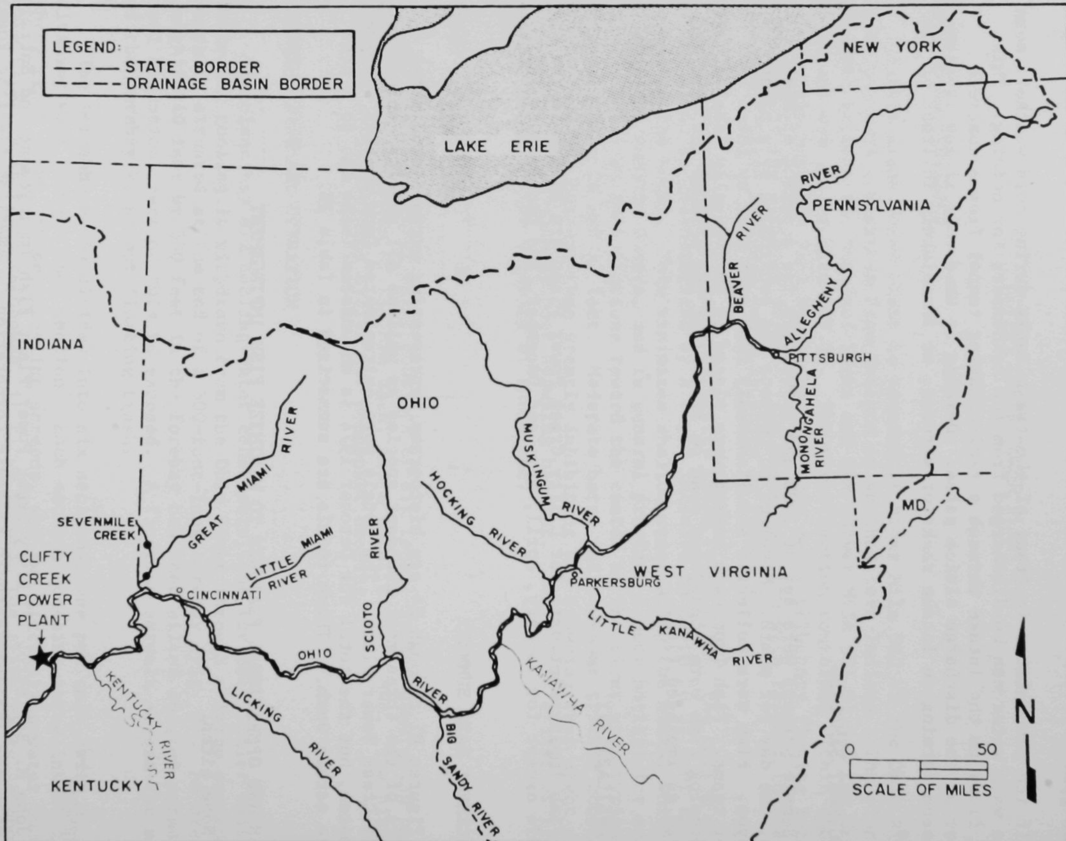


Fig. 1. Plant Location and Upper Ohio River Drainage Basin.

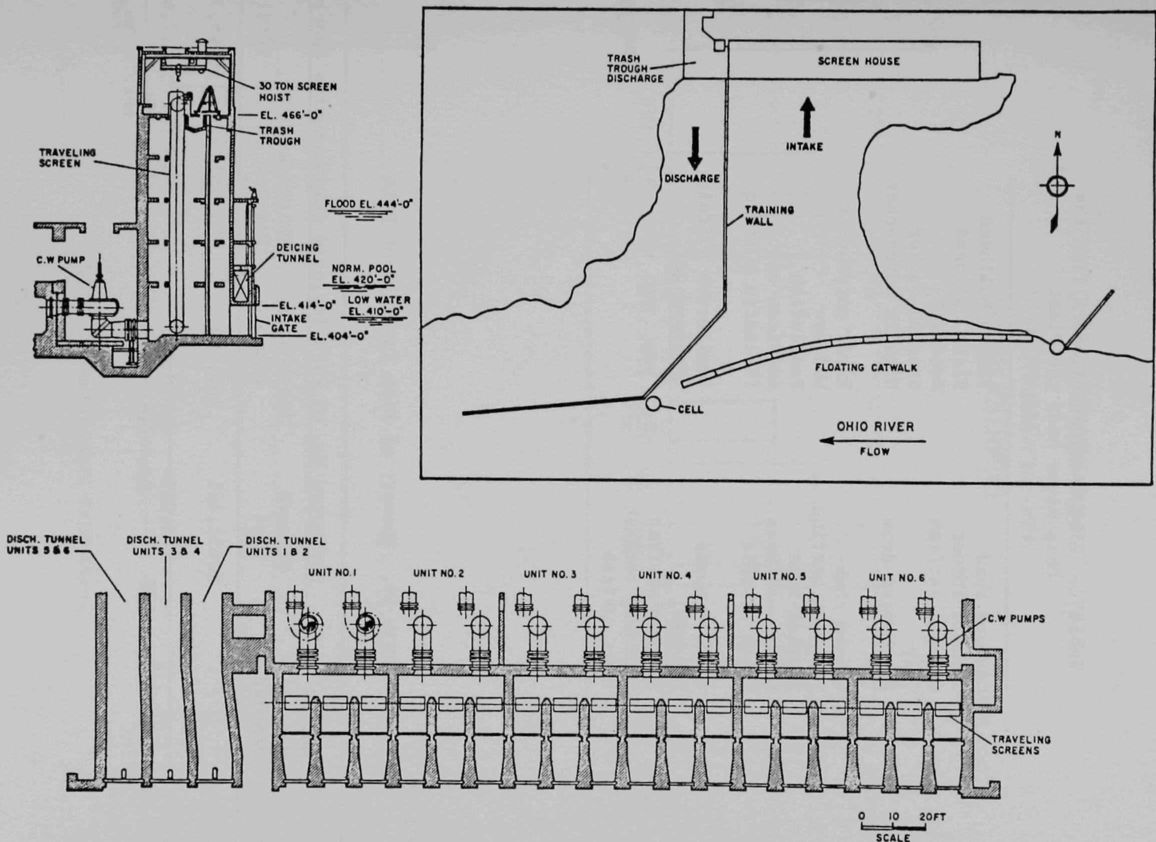


Fig. 2. Cooling-Water Intake and Discharge.

Table I. Fish Species Collected from the Ohio River near the Plant

Gizzard shad	Yellow bullhead
Emerald shiner	Black bullhead
Channel catfish	Goldfish
Carp	Spotted sucker
Freshwater drum	Highfin carpsucker
Silver chub	River carpsucker
Skipjack herring	Walleye
Spotted bass	Paddlefish
Largemouth bass	American eel
White crappie	Threadfin buffalo
Black crappie	Smallmouth buffalo
Bluegill	Longnose gar
Longear sunfish	
Flathead catfish	
Blue catfish	

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Gizzard Shad	Freshwater Drum	Skipjack Herring	Total
1974	8	1,481,421	160,750	47,352	1,695,398
1975	1	8,221	8,153	294	17,647

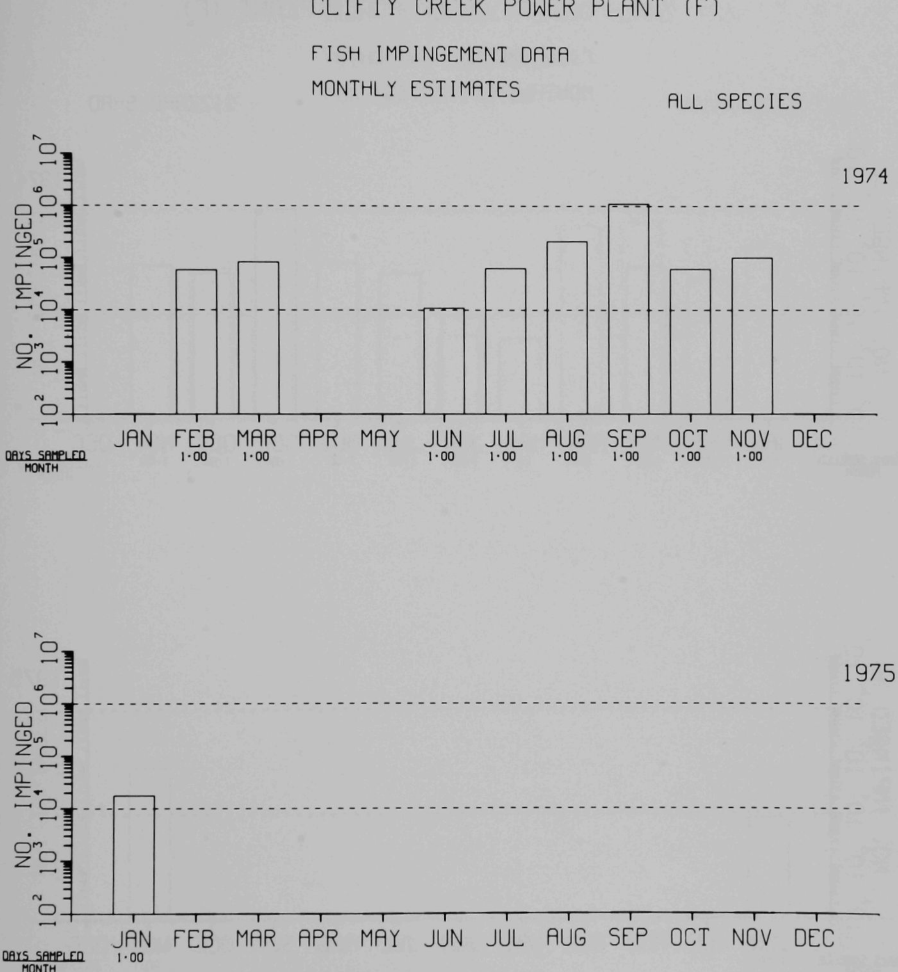


Fig. H1. Impingement Estimates.

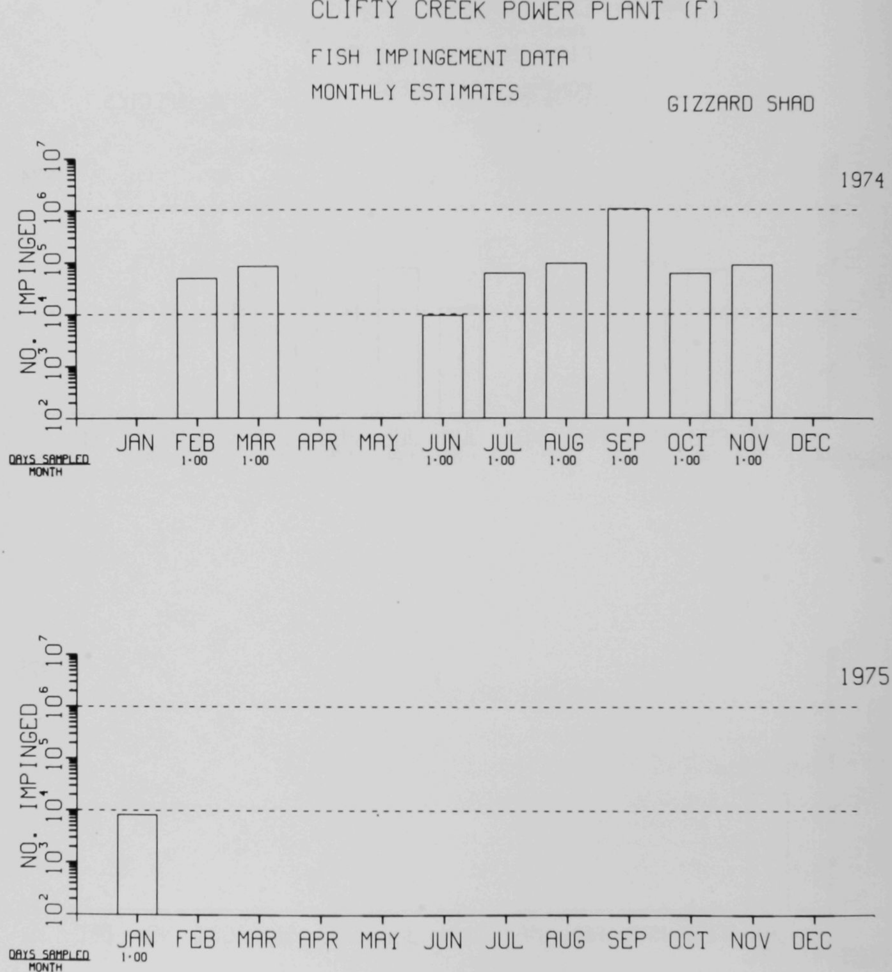


Fig. H2. Impingement Estimates.

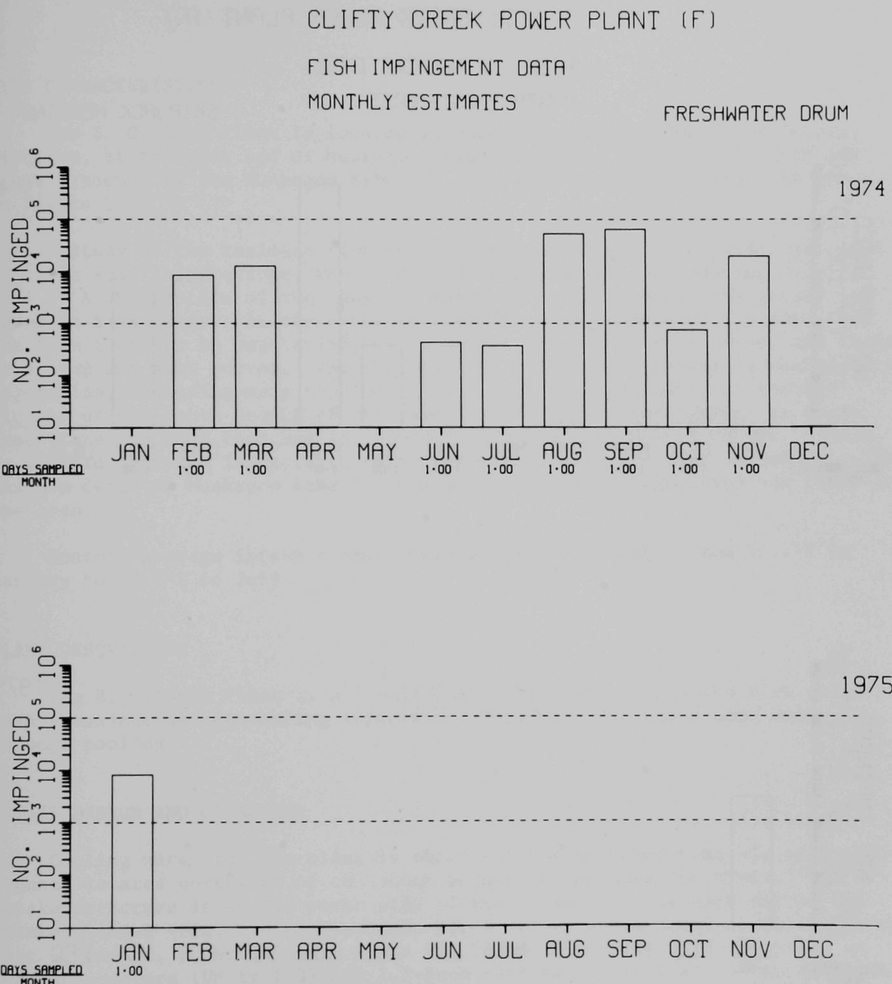


Fig. H3. Impingement Estimates.

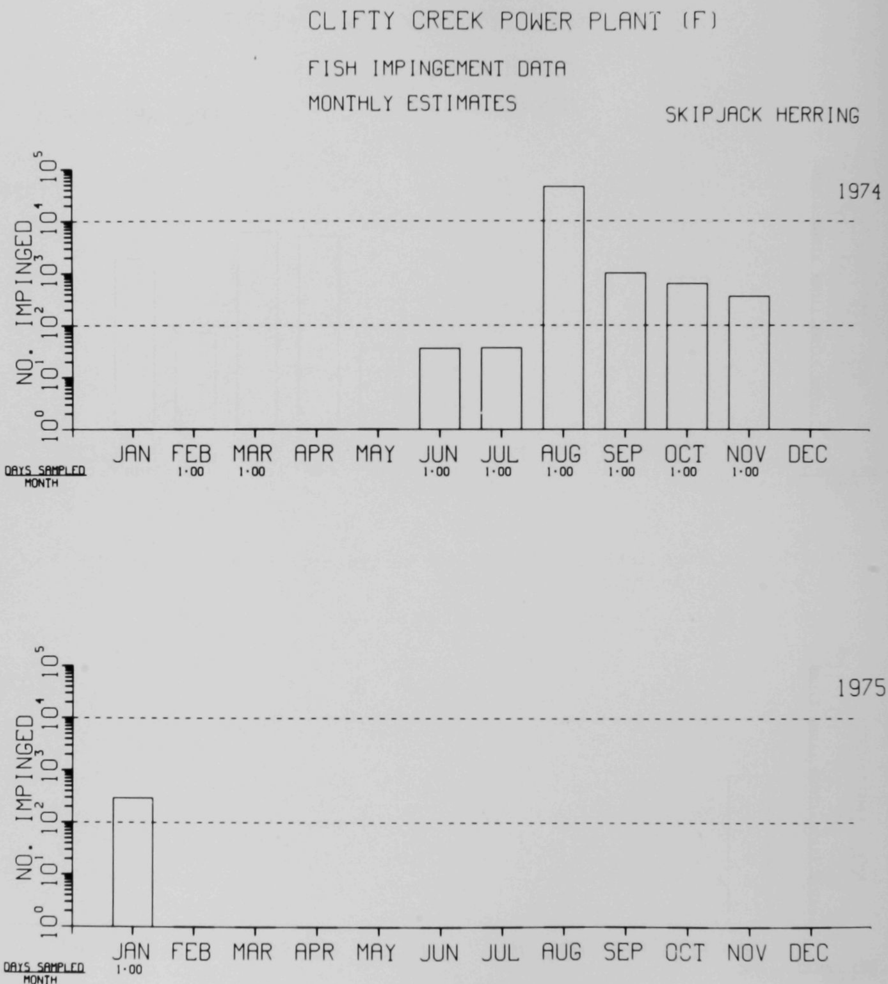


Fig. H4. Impingement Estimates.

B.C. COBB PLANT (F)

SITE CHARACTERISTICS

The B. C. Cobb Plant is located in Muskegon Township, Muskegon County, Michigan, at the east end of Muskegon Lake on a delta between the north and south branches of the Muskegon River.[1] An aerial view of the plant is shown in Figure 1.

A study of the resident fish population of Muskegon Lake, which involved thirteen sampling stations, was conducted by Limnetics, Inc. during July 1974.[2] A description of the range of habitats in the area of the intake is based on this study. At the confluence of the north branch of the river and the lake there is no vegetation, depth ranges from four to six feet, and there is a sand and silt bottom. The shoreline of the intake channel is choked with vegetation, including many toppled trees; the bottom is sand. At the confluence of the south branch of the river and the lake, the current is quite fast (three to four fps) and the shoreline is lined with rock rubble. There is a rapid increase in depth to five feet within eight feet of the shore. The maximum depth of Muskegon Lake is 24 feet. No aquatic vegetation was found in the area.

Monthly average intake temperatures during 1974 ranged from 37.4°F in January to 77.8°F in July.

PLANT DESCRIPTION

The B. C. Cobb Plant is a fossil-fueled facility comprising five units with a maximum net generating capacity of 531 MWe. The plant uses once-through cooling.

INTAKE DESIGN AND OPERATION

Cooling water for the plant is obtained from Muskegon Lake via an intake channel located northwest of the south branch of the Muskegon River. The intake structure is on the north side of the forebay at the east end of the intake channel (Fig. 2). Screenhouse No. 1 serves Units 1 and 2, No. 2 serves Unit 3, and No. 3 serves Units 4 and 5. Vertical iron trash bars spaced on two-inch centers (Units 1-3) and 1.5-inch centers (Units 4 and 5) are located at the face of each of the three screenhouses. Two vertical traveling screens are located in each of screenhouses Nos. 1 and 3, and one in No. 2. Each one has 3/8-inch-square mesh. Screen panels for Units 1-3 measure two feet by 5.25 feet and those for Units 4 and 5 measure two feet by 8.5 feet. The traveling screens are run automatically, with operation determined by a timer or by head loss across the screens, or manually depending on service requirements. Standard procedure is to operate the screens automatically at least once per eight-hour shift.

Units 1-3 each have two 27,500-gpm circulating-water pumps, and Units 4 and 5 each employ two 60,000-gpm pumps. Maximum cooling-water flow rate through the plant is 405,000 gpm. The calculated maximum velocity through the traveling screens is 1.21 fps for Units 1-3 and 1.13 fps for Units 4 and 5.

IMPINGEMENT SAMPLING

The traveling screens were operated either singly or together, depending on the number of fish impinged and the time available for screen counts. The operating times were determined by the established plant schedule. A total of 217 screen counts was made on 196 days from January 1974 through March 1975.

DATA AVAILABILITY

Impingement data for the B. C. Cobb Plant are available for January 1974 through March 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing the total numbers of the four most abundant species as well as all species impinged at the B. C. Cobb Plant. These totals are summarized in Table II. No screen counts were made during the week of 2-8 March 1975 because maintenance on the screens was being conducted.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCES

1. "Section 316(b) Intake Study - B. C. Cobb Plant." Consumers Power Company 30 June 1976.

2. "Preliminary Study of the Thermal Discharge from the B. C. Cobb Plant on Muskegon Lake and the Muskegon River." Limnetics, Inc., Milwaukee, Wisconsin. 12 December 1974.

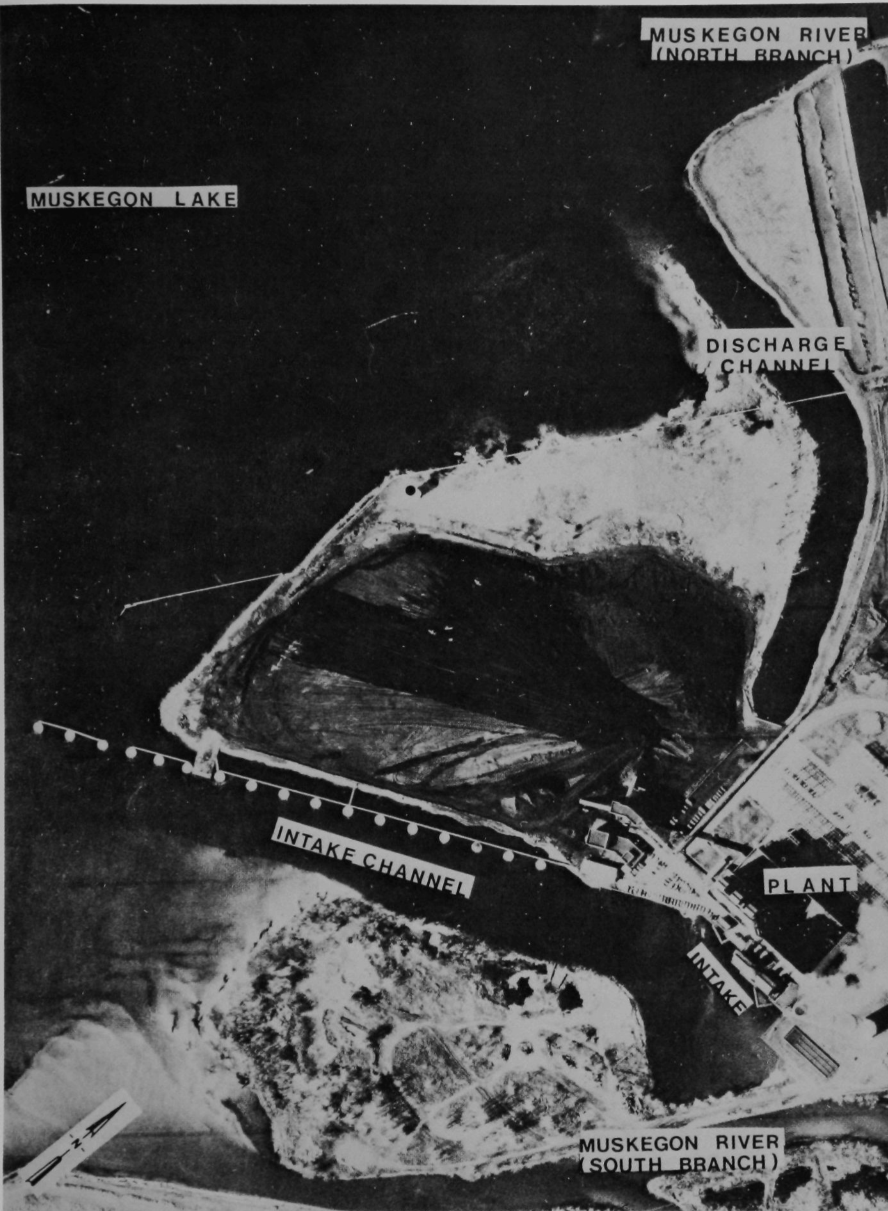


Fig. 1. Aerial View of the Plant and Vicinity.

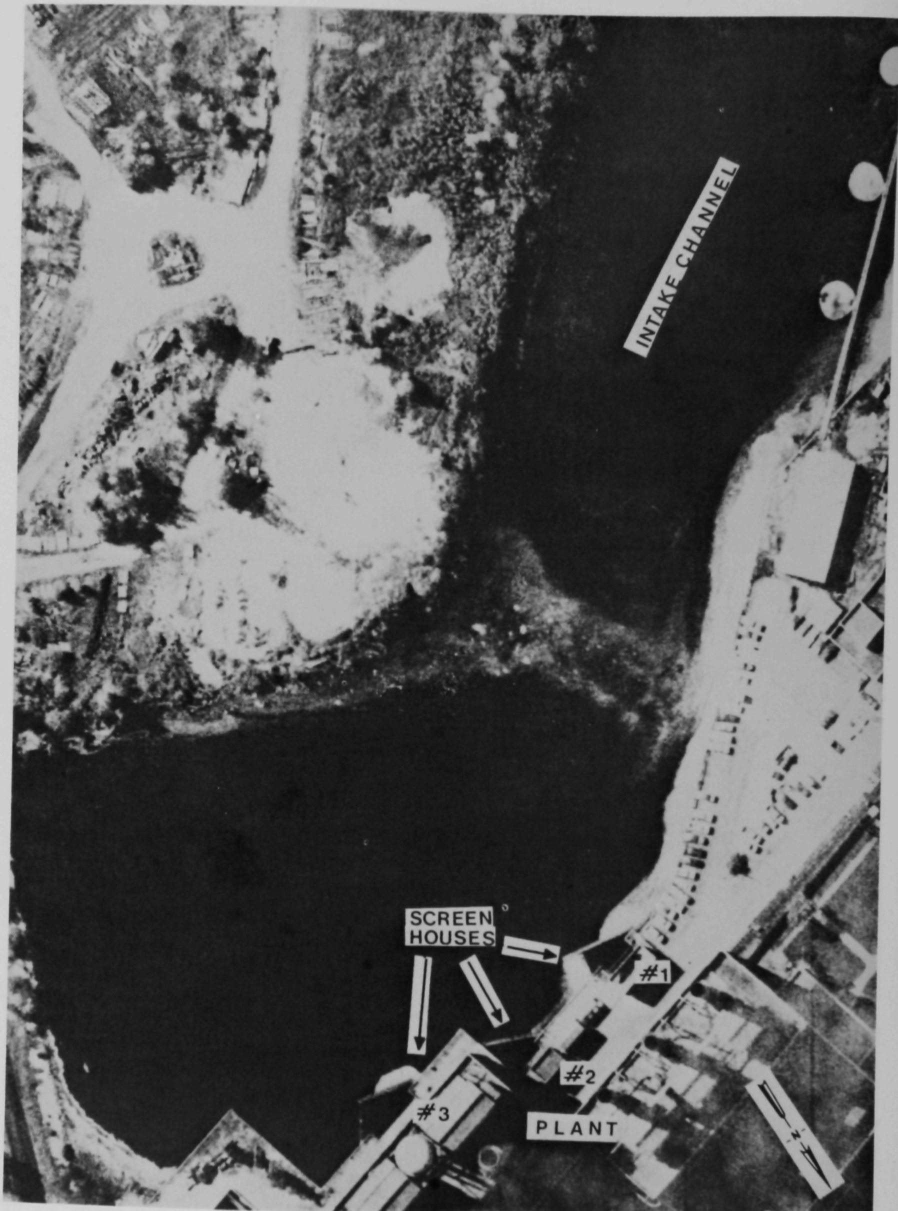


Fig. 2. Aerial View of the Intake Channel and Screenhouses.

Table I. Fishes Collected during the Intake Study of January 1974 to March 1975

Chestnut lamprey	Longnose sucker
Shovelnose sturgeon	Golden redhorse
Longnose gar	Shorthead redhorse
Bowfin	Silver redhorse
Alewife	Northern hog sucker
Gizzard shad	Flathead catfish
Coho salmon	Black bullhead
Chinook salmon	Yellow bullhead
Steelhead	Channel catfish
Brown trout	Tadpole madtom
Lake trout	Burbot
Rainbow smelt	Trout-perch
Central mudminnow	Brook silverside
Northern pike	Ninespine stickleback
Goldfish	Rock bass
Carp	Warmouth
Golden shiner	Green sunfish
Emerald shiner	Pumpkinseed
Spottail shiner	Bluegill
Blacknose shiner	Smallmouth bass
Common shiner	Largemouth bass
Creek chub	White crappie
River chub	Black crappie
Bluntnose minnow	Yellow perch
White sucker	Logperch
	Walleye
	Freshwater drum
	Slimy sculpin

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled				
		Northern Pike	Alewife	Trout-perch	Gizzard Shad	Total
1974	12	13,150	30,070	17,211	15,994	95,534
1975	3	1,880	5,313	2,316	137,440	157,017

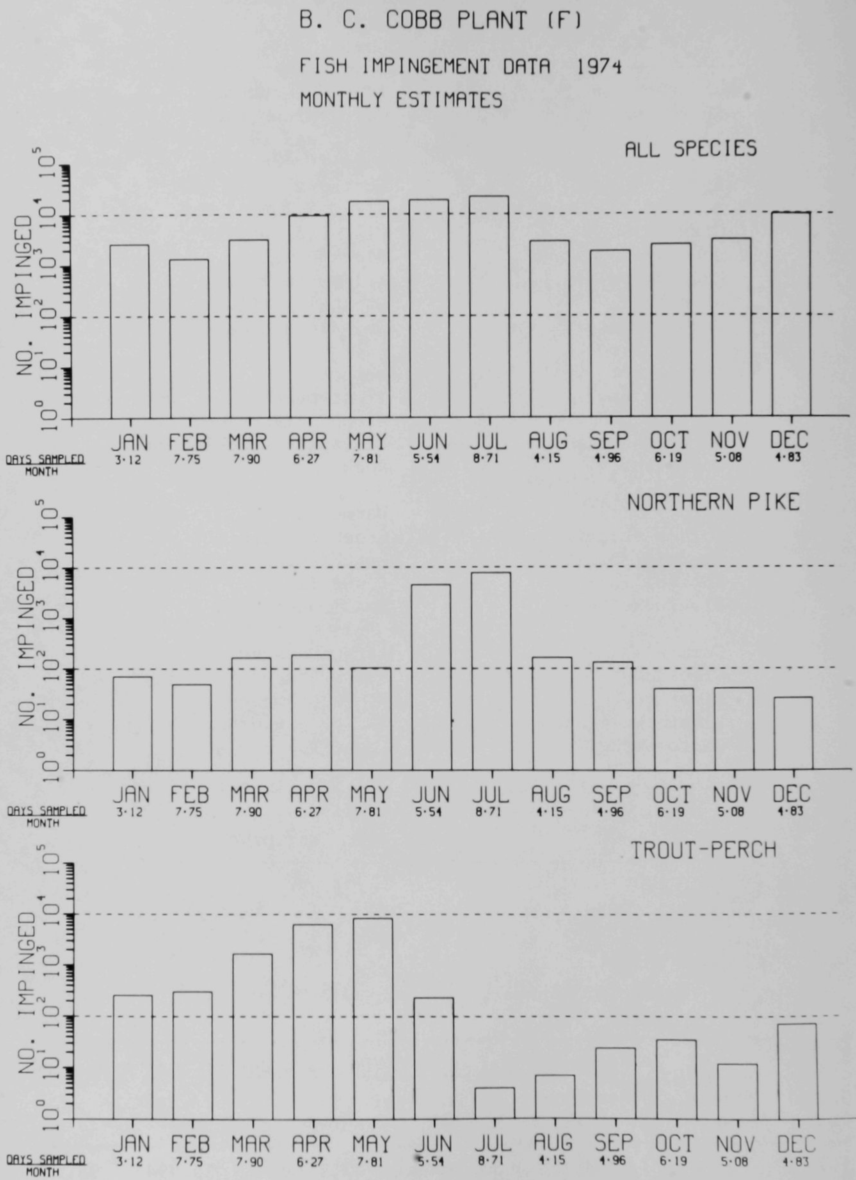


Fig. H1. Impingement Estimates.

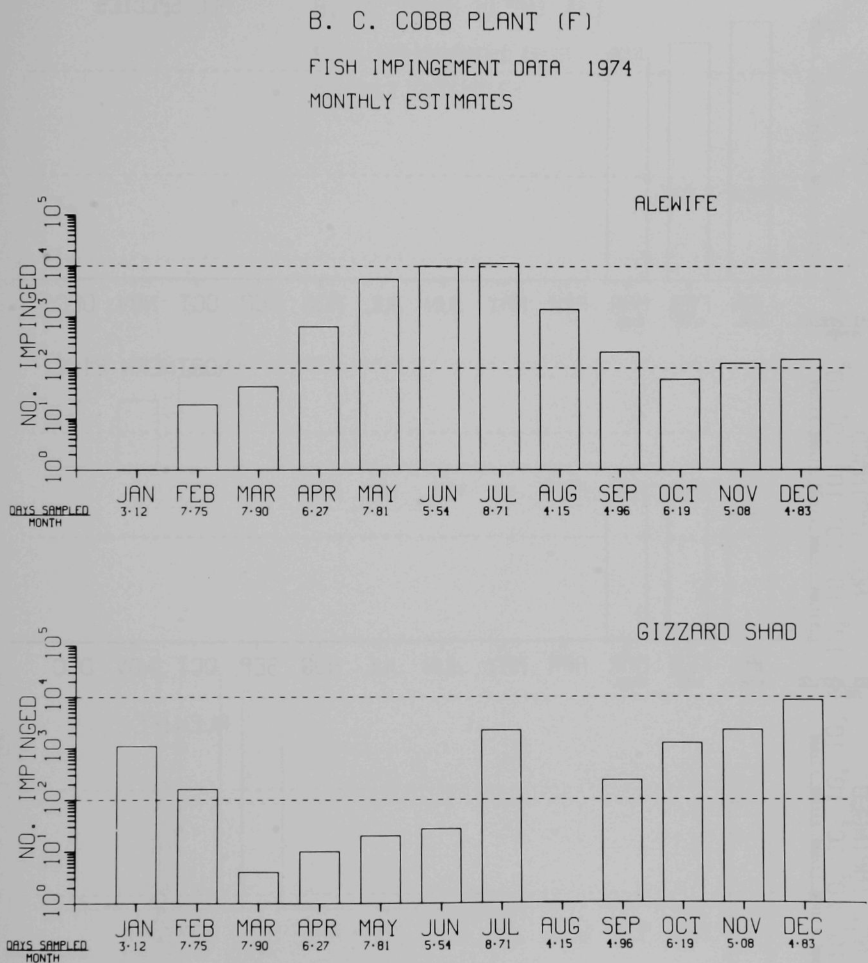


Fig. H2. Impingement Estimates.

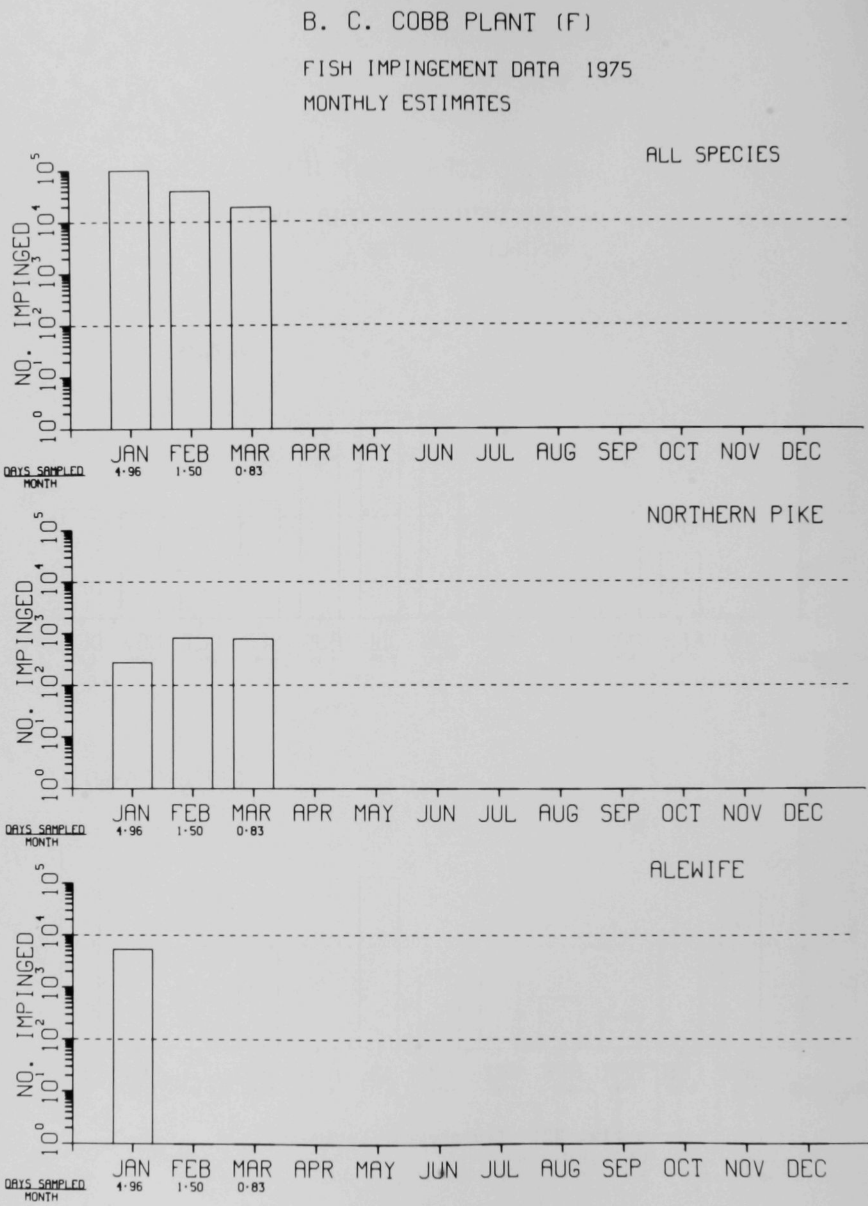


Fig. H3. Impingement Estimates.

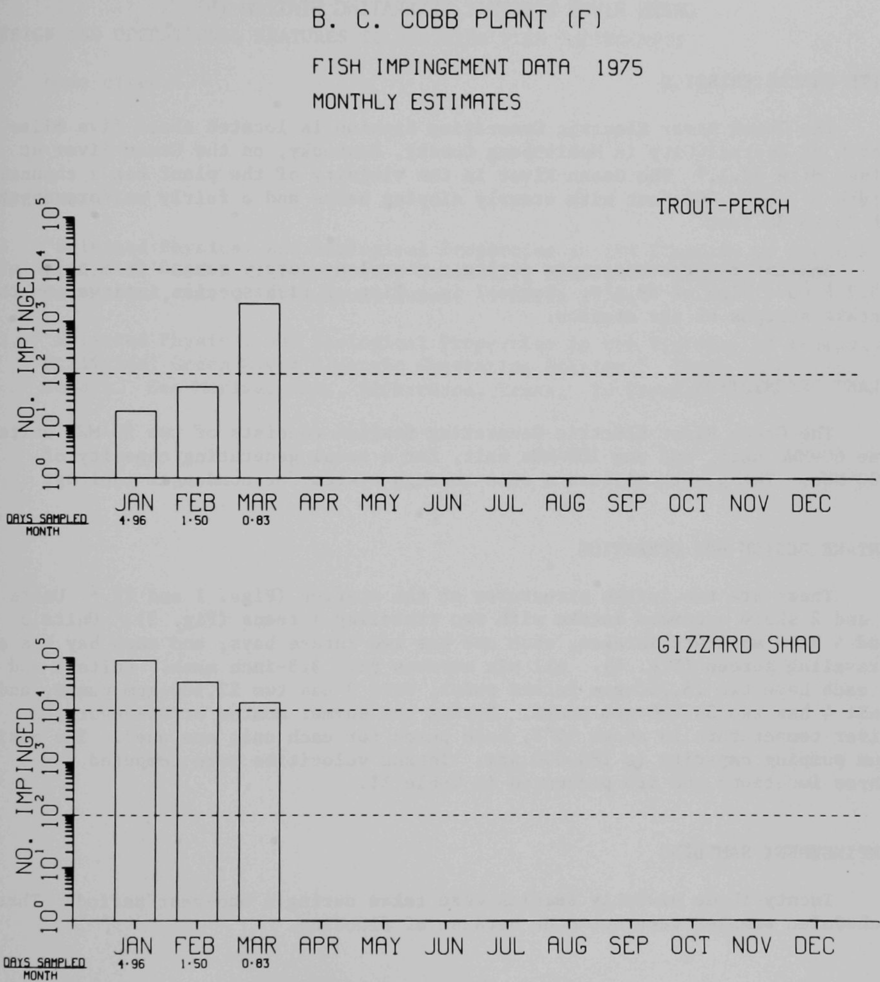


Fig. H4. Impingement Estimates.

GREEN RIVER ELECTRIC GENERATING STATION (F)

SITE CHARACTERISTICS

The Green River Electric Generating Station is located about five miles north of Central City in Muhlenberg County, Kentucky, on the Green River at River Mile 82.3.[1] The Green River in the vicinity of the plant has a channel width of about 400 feet with steeply sloping banks and a fairly uniform depth of 25 to 30 feet.

Ambient river temperature during a year-long survey ranged from a low of 63.2°F to a high of 89.6°F. Table I is a list of fish species impinged on the intake screens at the station.

PLANT DESCRIPTION

The Green River Electric Generating Station consists of two 30-MWe units, one 60-MWe unit, and one 100-MWe unit, for a total generating capacity of 220 MWe. The plant utilizes a once-through system for condenser cooling.

INTAKE DESIGN AND OPERATION

There are two intake structures at the station (Figs. 1 and 2).[2] Units 1 and 2 share a common intake with two traveling screens (Fig. 3). Units 3 and 4 have separate intakes, each one has two intake bays, and each bay has a traveling screen (Fig. 4). All six screens have 3/8-inch mesh. Units 1 and 2 each have two 15,750-gpm intake pumps, Unit 3 has two 27,500-gpm pumps, and Unit 4 has two 34,000-gpm pumps. During the summer months or whenever the river temperature is above 50°F, both pumps for each unit are used. The maximum pumping capacity is 186,000 gpm. Intake velocities were computed for three locations and are presented in Table II.

IMPINGEMENT SAMPLING

Twenty-three biweekly samples were taken during a one-year period. Three scheduled samples were not made because of flooding.

DATA AVAILABILITY

Impingement data for the station are available for November 1974 through October 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing the three most abundant species as well as all species impinged at the station. Table III summarizes these totals.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCES

1. "Selected Physical and Biological Properties in the Vicinity of Kentucky Utilities' Green River Electric Generating Station." Summary Report. Geo-Marine, Inc., Richardson, Texas. 9 March 1976.

2. "Selected Physical and Biological Properties in the Vicinity of Kentucky Utilities' Green River Electric Generating Station." First Quarterly Report. Geo-Marine, Inc., Richardson, Texas. 10 February 1975.

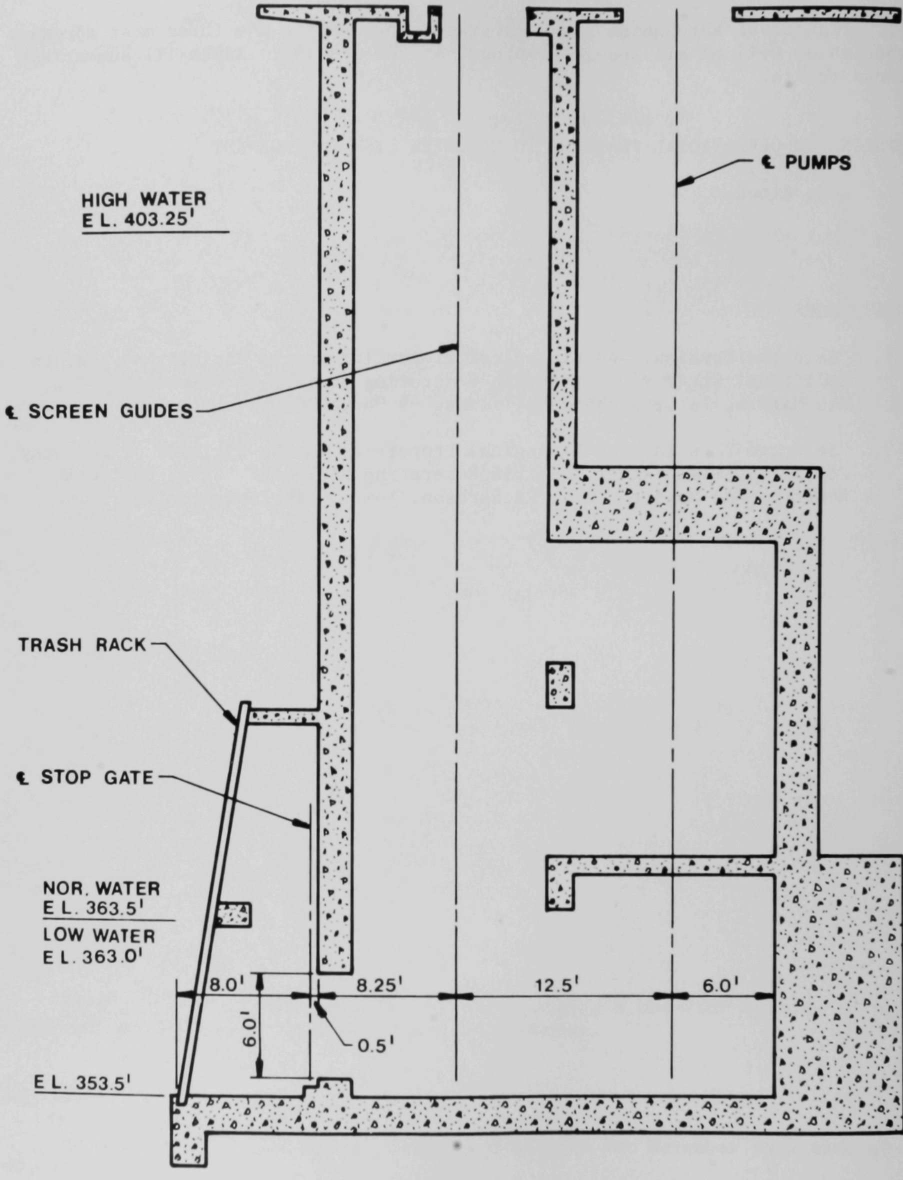


Fig. 1. Intake Structure, Side View, Units 1 and 2.

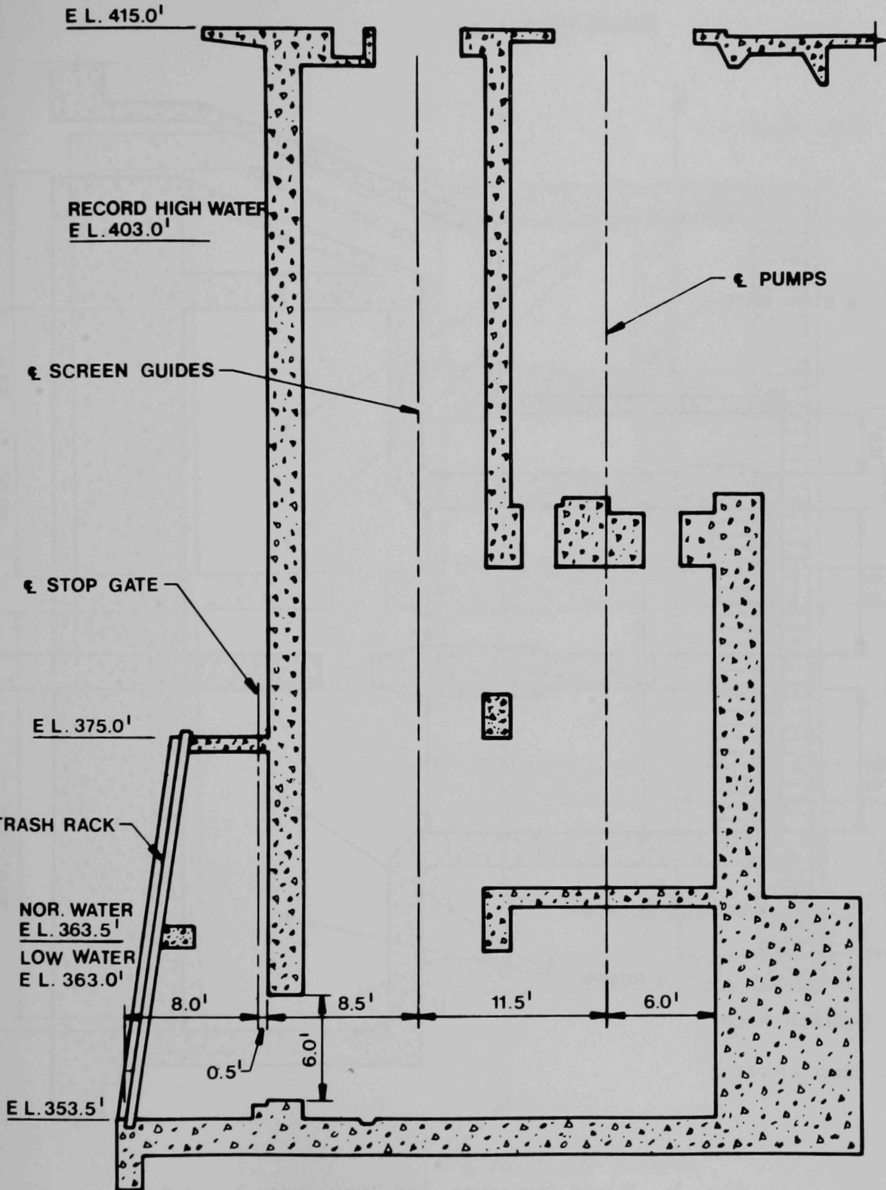


Fig. 2. Intake Structure, Side View, Units 3 and 4.

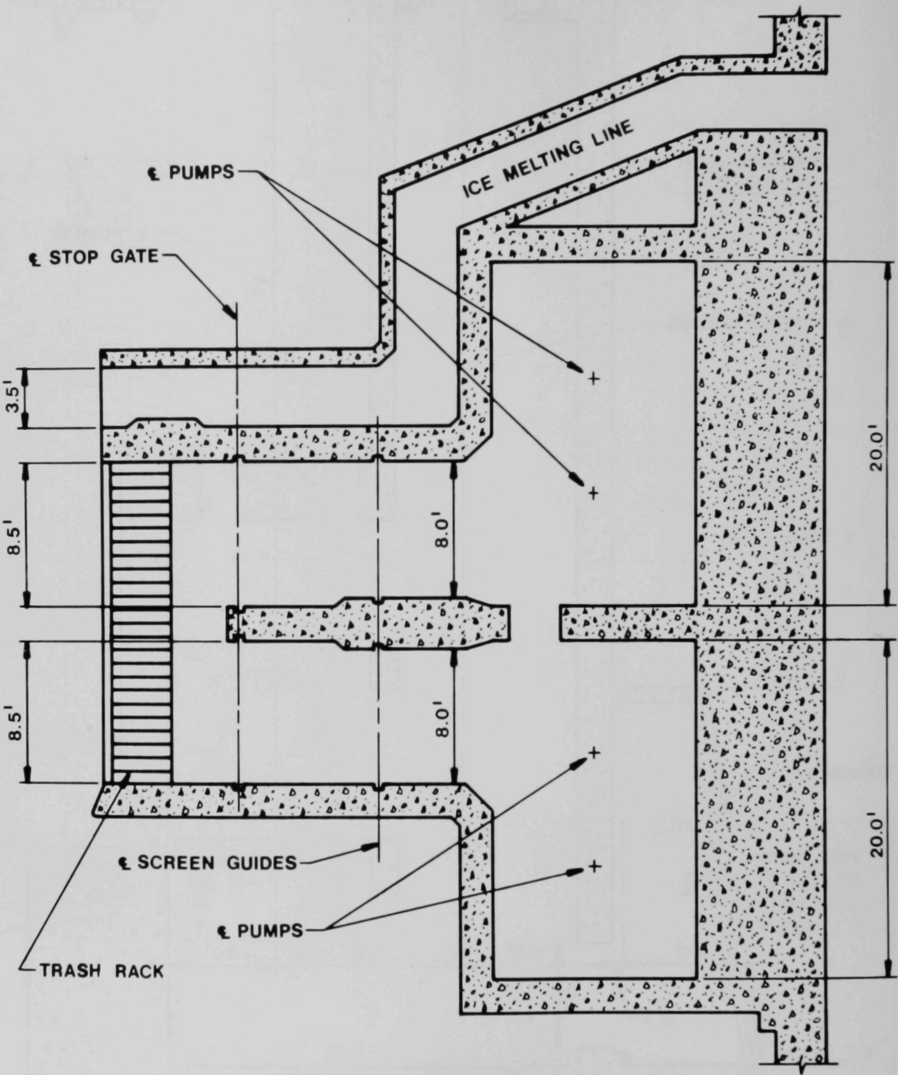


Fig. 3. Intake Structure, Top View, Units 1 and 2.

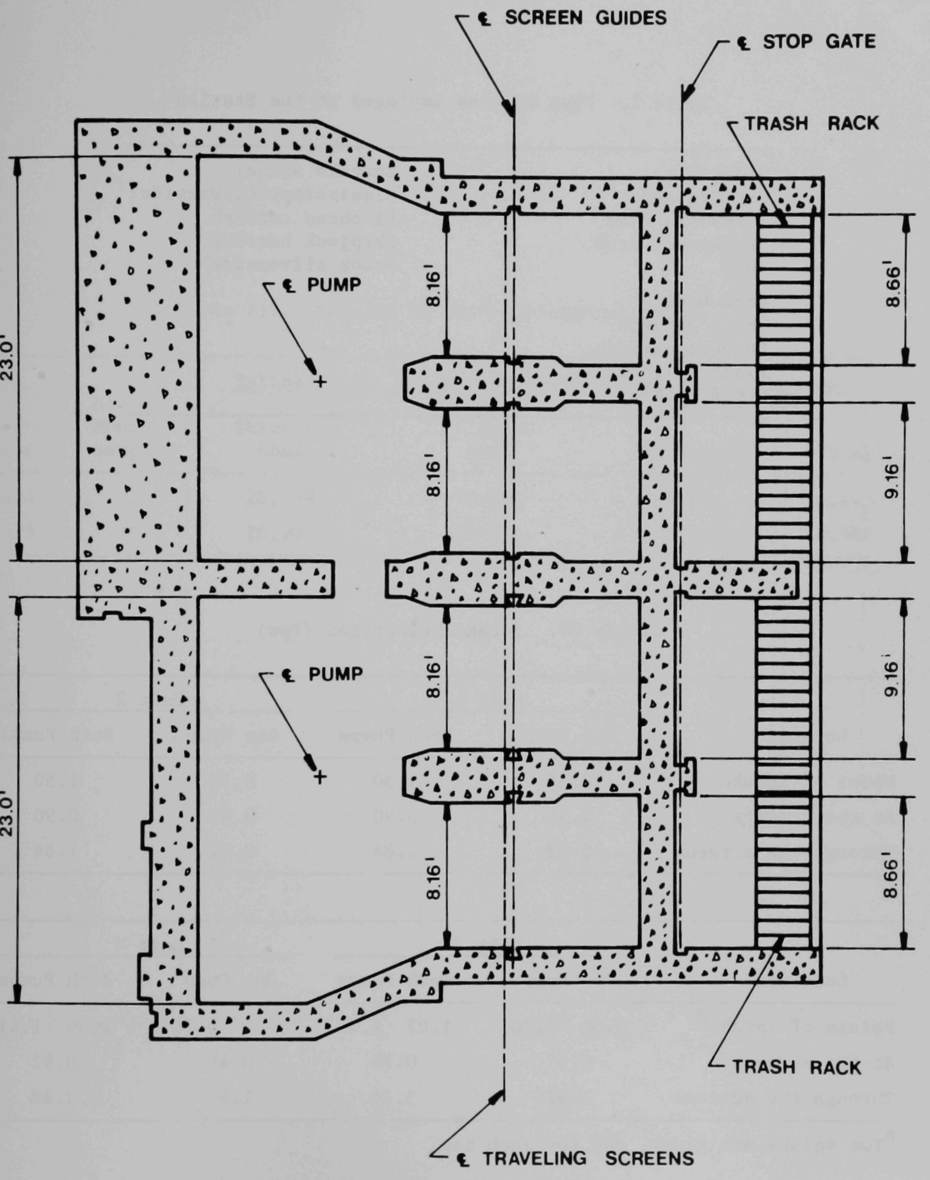


Fig. 4. Intake Structure, Top View, Units 3 and 4.

Table I. Fish Species Impinged at the Station

Bluegill	Emerald shiner
Gizzard shad	Mississippi silverside
Threadfin shad	Flathead catfish
Freshwater drum	Skipjack herring
Carp	Brook silverside
Rock bass	
White crappie	
Channel catfish	
Black bullhead	
Green sunfish	

Table II. Intake Velocities (fps)

Location	Unit 1		Unit 2	
	One Pump	Both Pumps	One Pump	Both Pumps
Point of intake	0.75	1.50	0.75	1.50
At the screens	0.45	0.90	0.45	0.90
Through the screens	0.92	1.84	0.92	1.84

Location	Unit 3		Unit 4	
	One Pump	Both Pumps	One Pump	Both Pumps
Points of intake[a]	0.60 0.70	1.21 1.41	0.74 0.70	1.49 1.41
At the screens	0.37	0.75	0.46	0.92
Through the screens	1.57	3.14	1.94	3.88

[a]Two values are given, one for each bay.

Table III. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Threadfin Shad	Gizzard Shad	Bluegill	Total
1974	2	22,489	1,641	71	24,423
1975	10	10,297	28,971	789	43,582

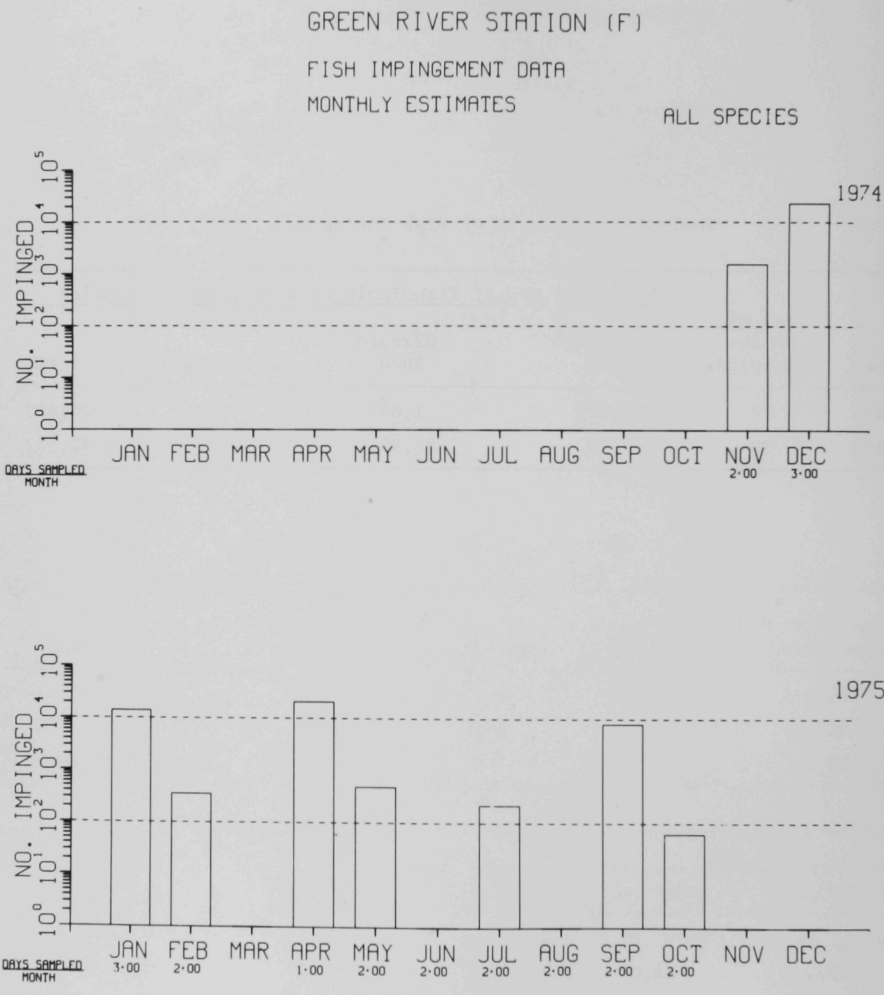


Fig. H1. Impingement Estimates.

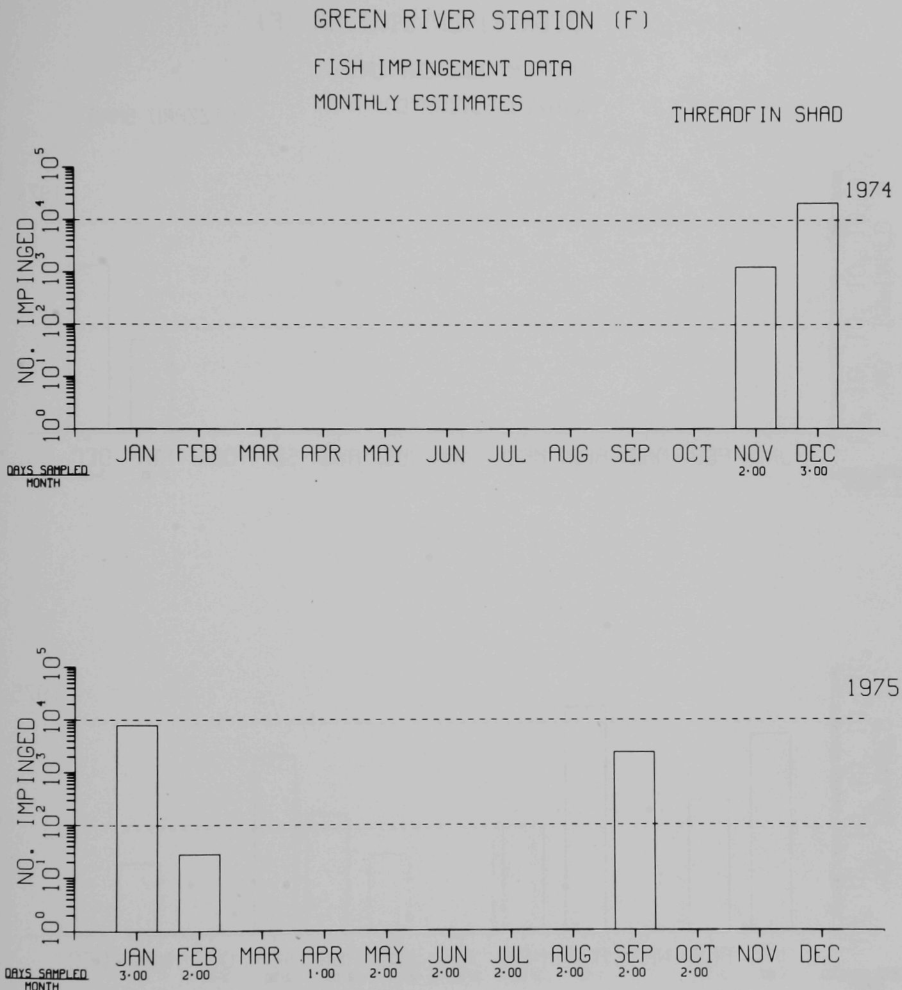


Fig. H2. Impingement Estimates.

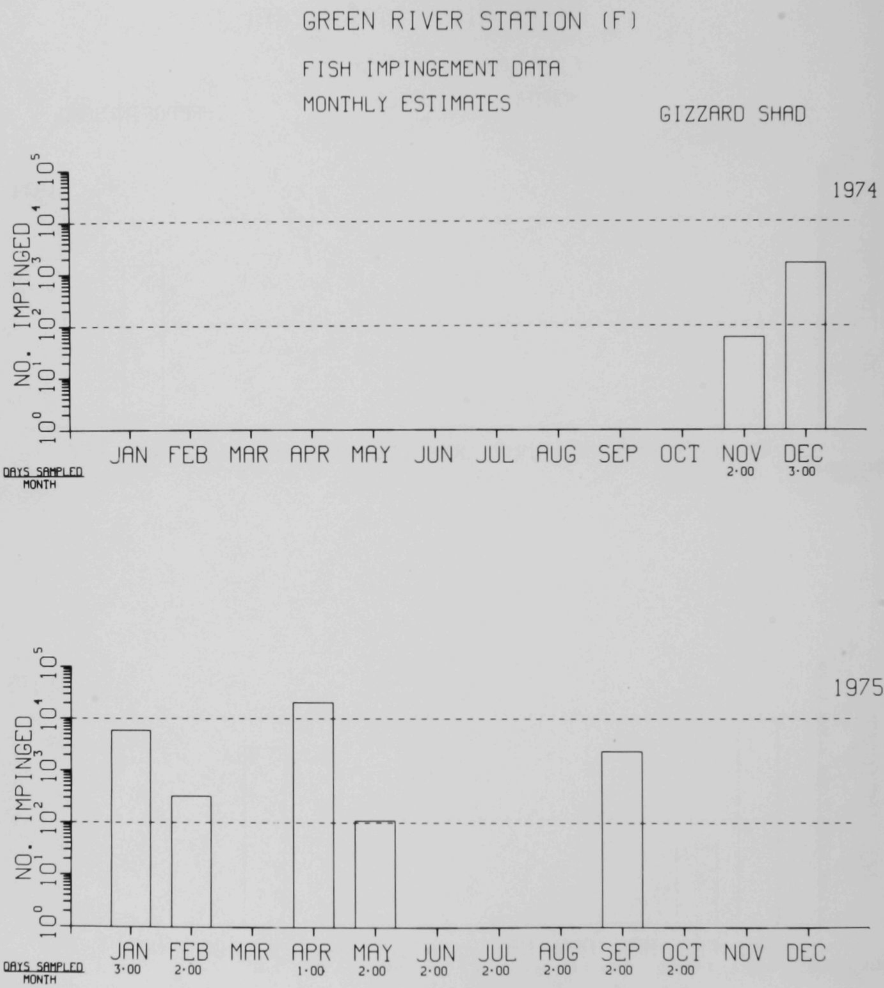
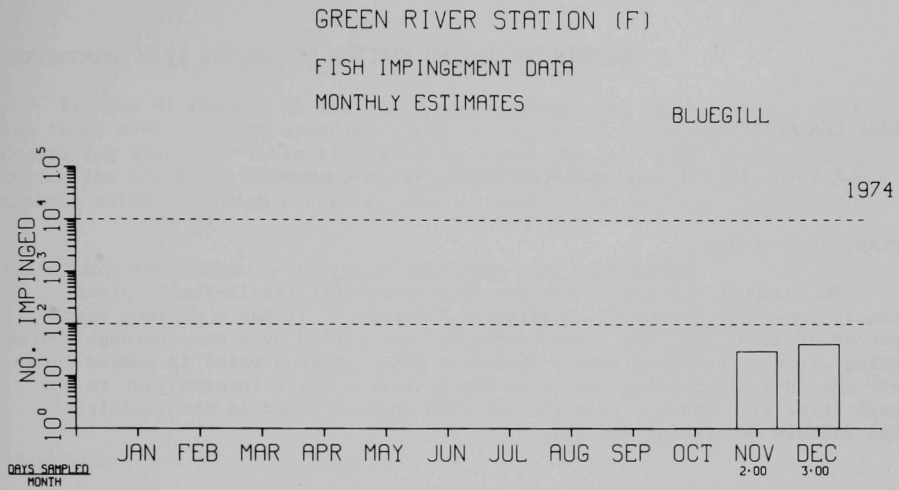


Fig. H3. Impingement Estimates.



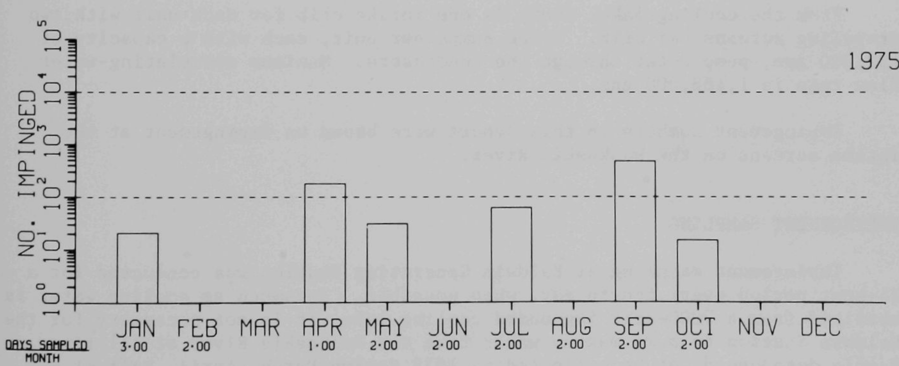


Fig. H4. Impingement Estimates.

BALDWIN GENERATING STATION (F)

SITE CHARACTERISTICS

Information on site characteristics was not provided.

PLANT DESCRIPTION

The Baldwin Generating Station is a three-unit fossil-fueled plant located one mile northwest of Baldwin, Illinois.[1] It has a maximum total output of about 1850 MWe. The condensers are cooled by a once-through system using circulating water from a 2000-acre lake. Makeup water is pumped into the closed-cycle cooling lake from the Kaskaskia River located just to the west (Fig. 1). Table I is a list of fish species found in the vicinity of the Baldwin Generating Station.

INTAKE DESIGN AND OPERATION

Water is initially pumped into the cooling lake by three 12,500-gpm pumps. The water is withdrawn from the Kaskaskia River through two sets of traveling screens.

From the cooling lake, there is one intake crib for each unit with two traveling screens per crib. Three pumps per unit, each with a capacity of 132,000 gpm, pump water through the condensers. Maximum circulating-water flow rate is 1,188,000 gpm.

Impingement numbers in this report were based on impingement at the intake screens on the Kaskaskia River.

IMPINGEMENT SAMPLING

Impingement sampling at Baldwin Generating Station was conducted for a 24-hour period every fourth day, when possible. Inasmuch as cooling water is obtained from a 2000-acre impounded cooling lake, it is not necessary for the Baldwin Station to pump makeup water from the Kaskaskia River at all times. Sample data could not be collected in 1975 during March, April, half of May, and two periods in February and June.

DATA AVAILABILITY

Fish impingement data for the Baldwin Generating Station are available for December 1974 through November 1975, with the exceptions noted above.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing extrapolated totals for the three most abundant species as well as all species impinged at the Baldwin Generating Station. Table II summarizes these totals. High impingement rates during the months of December, January, and February were due to the poikilothermic nature and high mortality rate of shad in low ambient temperatures.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCE

1. "Screen Impingement Studies at the Baldwin - Illinois Power Company - Generating Plant - December 1974 to November 1975." Wapora, Inc., Charleston, Illinois. 5 December 1975.

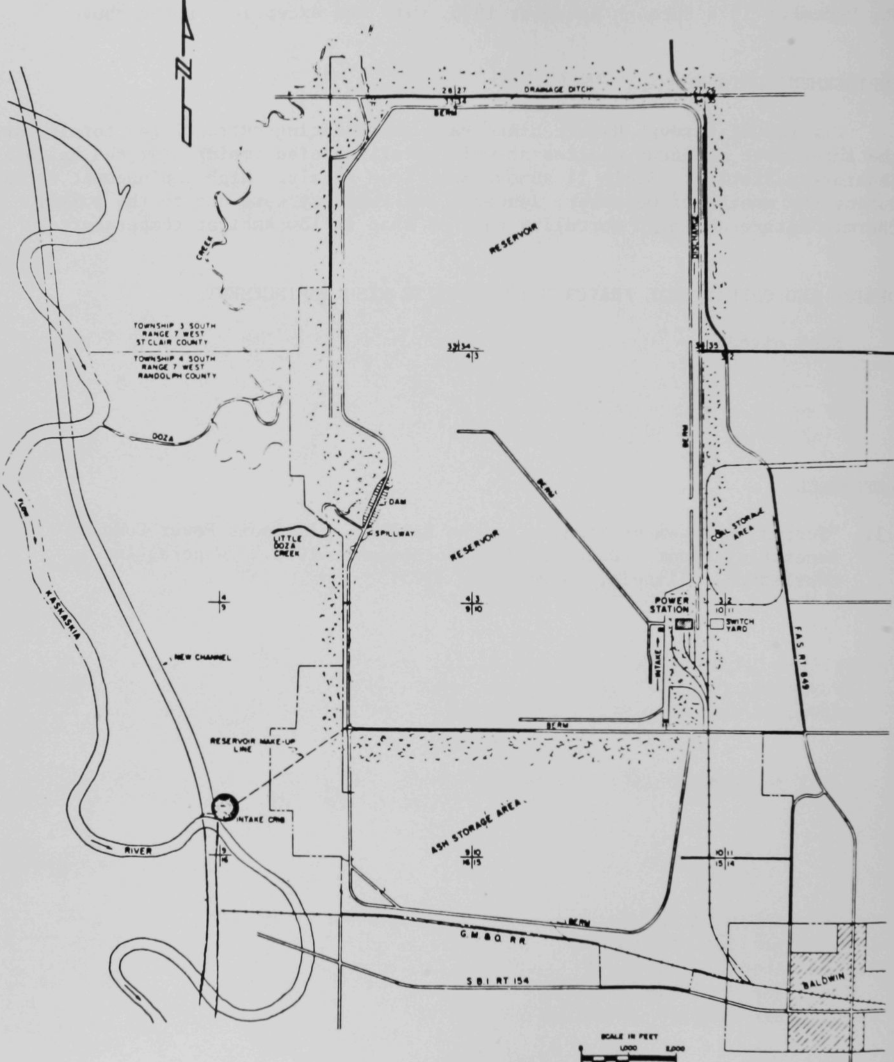


Fig. 1. Location of Station Facilities.

Table I. Fish Species Collected in the Vicinity of the Station

Gizzard shad	Black crappie
Carp	Sauger
Bluegill	Freshwater drum
Largemouth bass	Smallmouth buffalo
White crappie	Bigmouth buffalo
	Black bullhead
	Channel catfish
	Flathead catfish
	White bass

Table II. Summary of Fish Impingement Data

		Estimated No. of Fish Impinged during Months Sampled			
Year	No. of Months Sampled	Gizzard Shad	Freshwater Drum	Flathead Catfish	Total
1974	1	19,092	0	0	19,092
1975	9	275,064	1,589	251	277,300

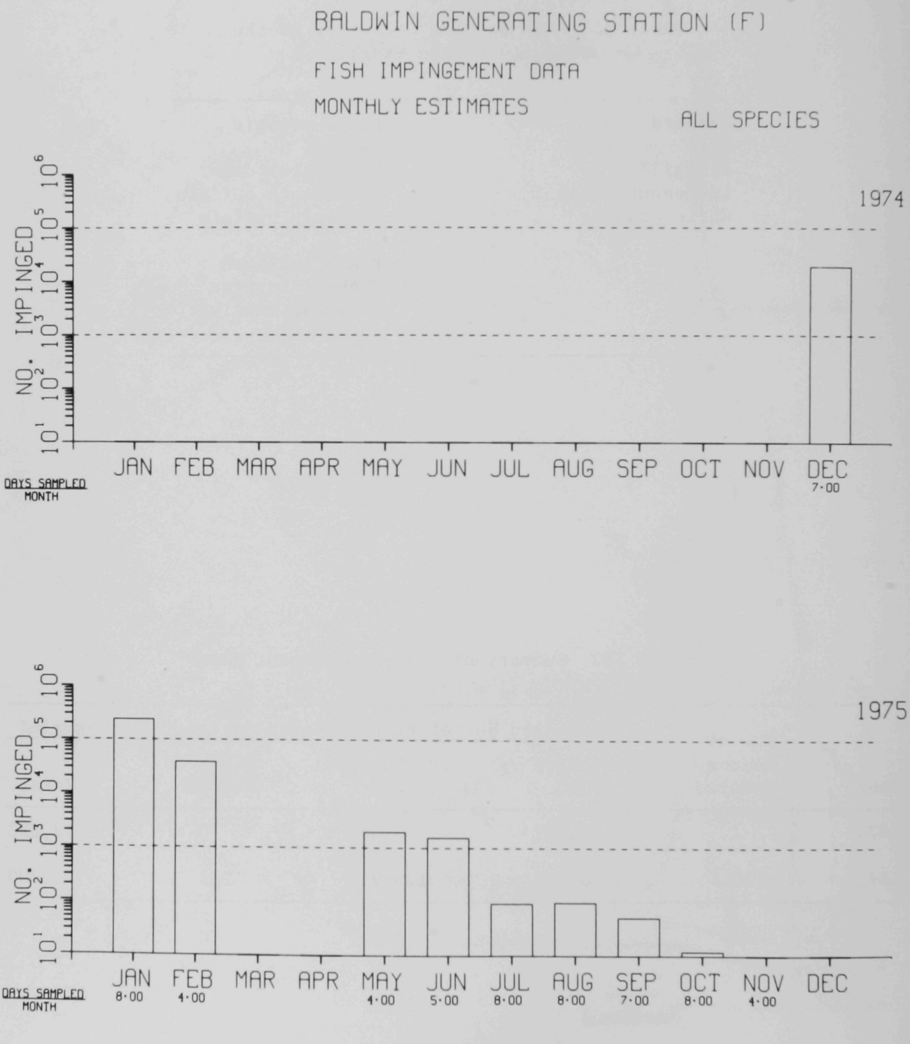


Fig. H1. Impingement Estimates.

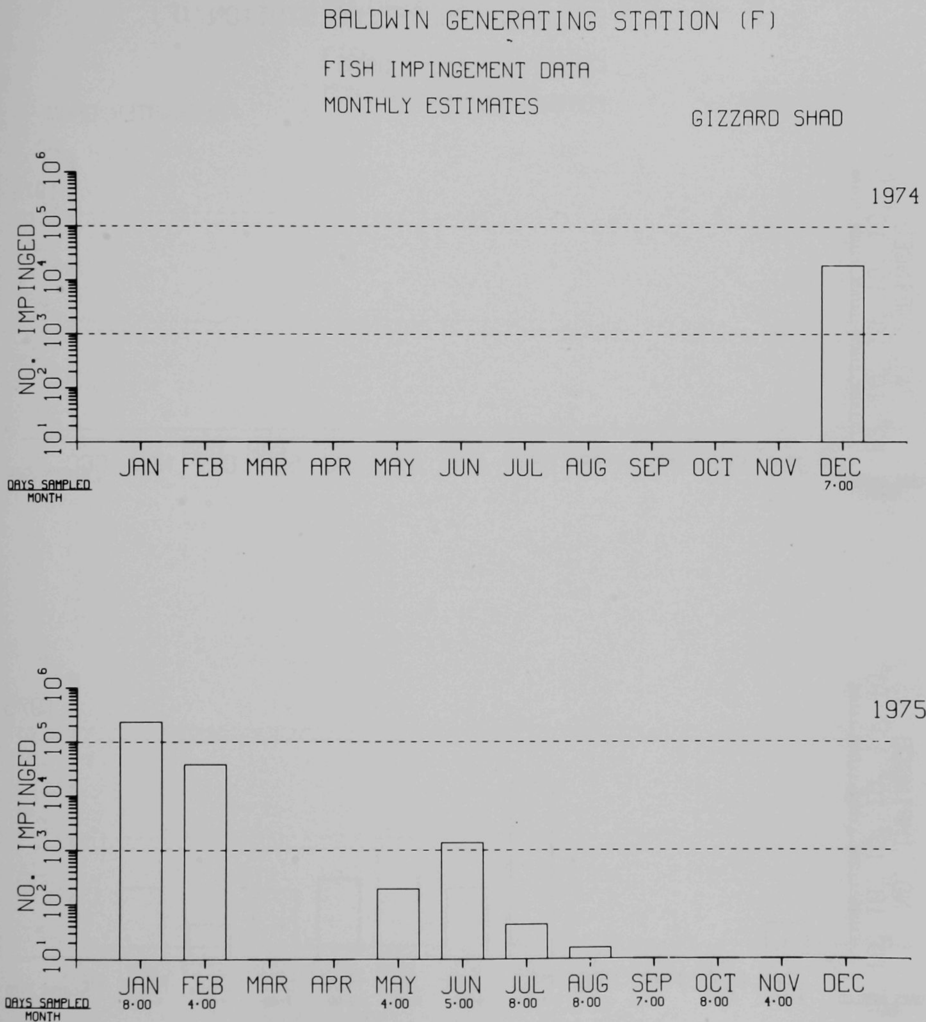


Fig. H2. Impingement Estimates.

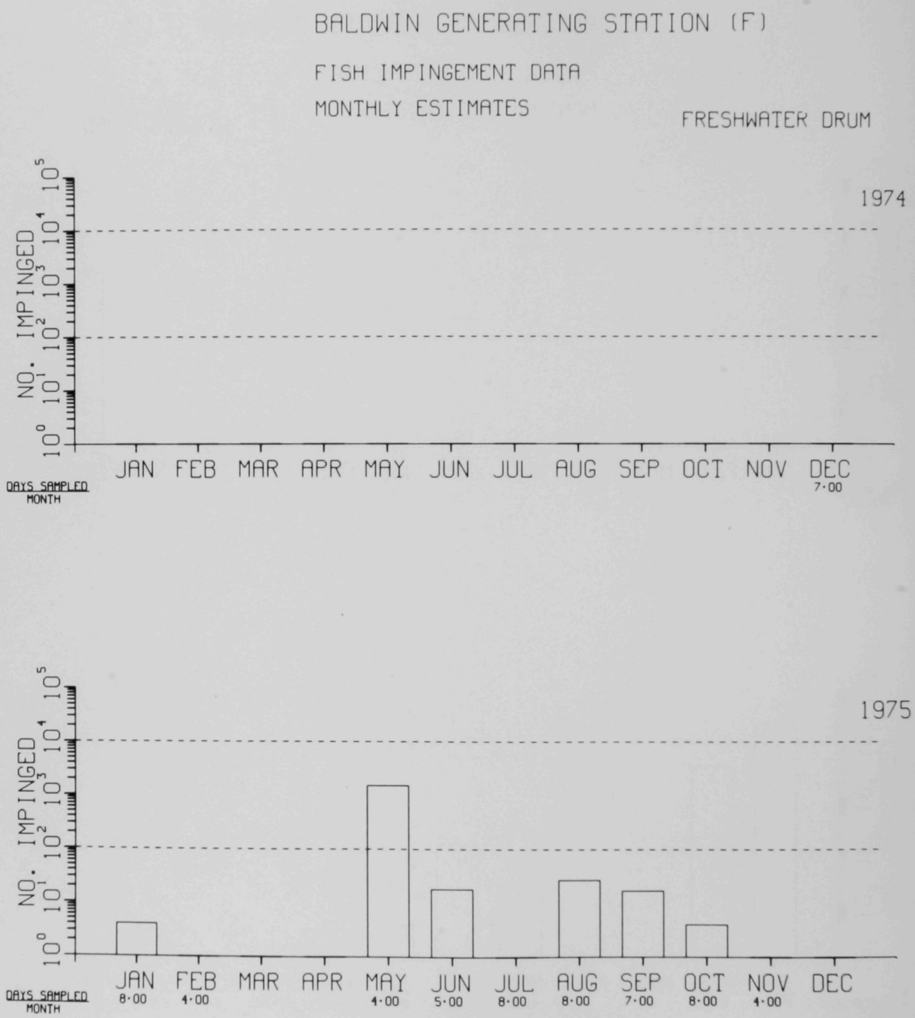


Fig. H3. Impingement Estimates.

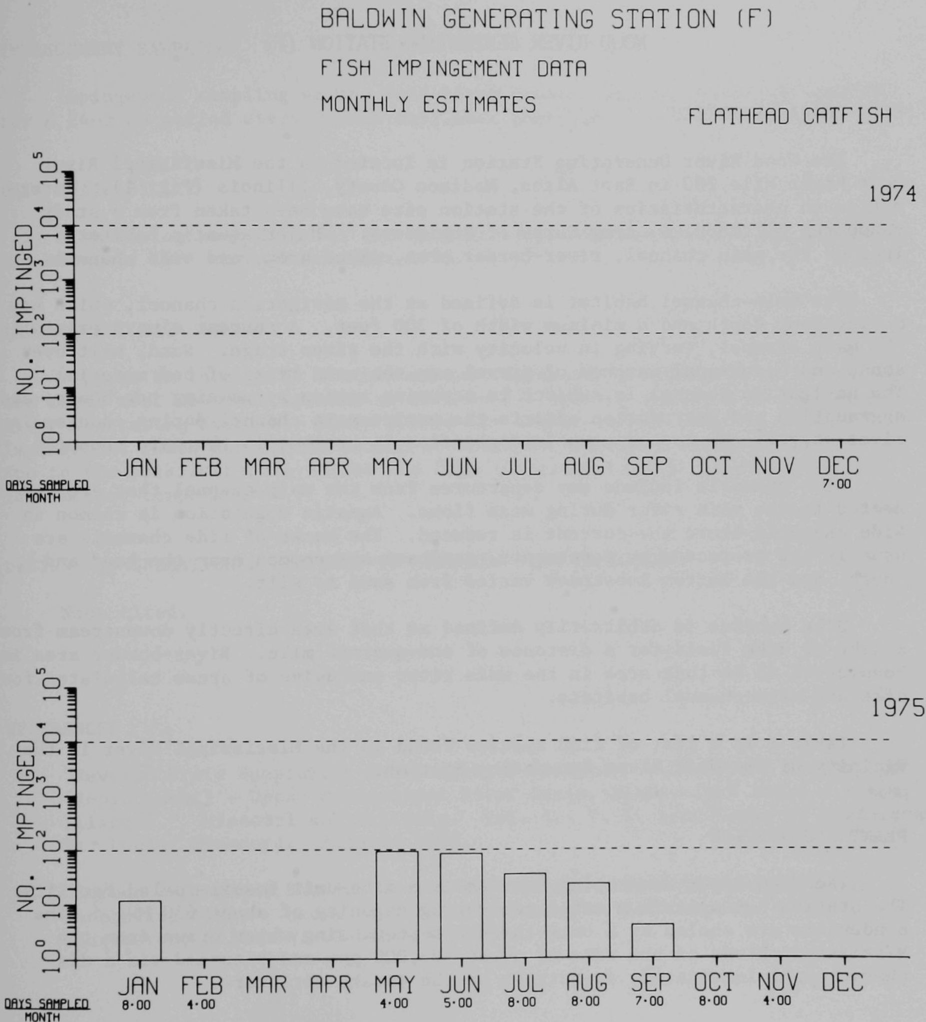


Fig. H4. Impingement Estimates.

WOOD RIVER GENERATING STATION (F)

SITE CHARACTERISTICS

The Wood River Generating Station is located on the Mississippi River near River Mile 200 in East Alton, Madison County, Illinois (Fig. 1). Information on characteristics of the station site have been taken from a study conducted by the U. S. Army Corps of Engineers.[1] Major aquatic habitats include the main channel, river-border area, diked area, and side channels.

The main-channel habitat is defined as the navigation channel, which has a nine-foot depth and a minimum width of 300 feet. A current always exists in the main channel, varying in velocity with the river stage. Sand, silt over sand, and occasional patches of gravel are the main types of bed material. The navigation channel is subject to scouring action by passing tow boats, and aggradation and degradation affects the entire main channel during changes in river stages. No rooted aquatic vegetation is present in the main channel.

Side channels include any departures from the main channel that are connected to the main river during mean flows. Aquatic vegetation is common in side channels where the current is reduced. The banks of side channels are usually not protected by revetments, sandbars are common near the head and mouth, and the bottom substrate varies from sand to silt.

Dike habitat is arbitrarily defined as that area directly downstream from a dike or dike field for a distance of one-quarter mile. River-border area is considered to be that area in the main river exclusive of areas calculated for dike and main-channel habitats.

Table I is a list of fish species found in the Mississippi River in the vicinity of the Wood River Generating Station.

PLANT DESCRIPTION

The Wood River Generating Station is a five-unit fossil-fueled facility. The station has a maximum total generating capacity of about 650 MWe.[2] The condensers are cooled by a once-through system using water drawn from the Mississippi River at the rate of about 429,000 gpm and returned via a discharge canal immediately downstream of the intake structure.

INTAKE DESIGN AND OPERATION

Cooling water is drawn from the Mississippi River through a crib house to the station. Each of the five units has two circulating-water pumps. Units

1-3 utilize 37,000-gpm pumps, Unit 4 utilizes 33,250-gpm pumps, and Unit 5 utilizes 70,000-gpm pumps. Total maximum capacity is 428,500 gpm.

Discharge water is used for deicing in the winter months.

IMPINGEMENT SAMPLING

Impingement sampling at the Wood River Generating Station was conducted for a 24-hour period every fourth day, when possible.

DATA AVAILABILITY

Fish impingement data for the Wood River Generating Station are available for December 1974 through November 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing extrapolated totals of the three most abundant species as well as all species impinged at the Wood River Generating Station. These totals are summarized in Table II. High impingement rates during the months of December, January, and February were due to the poikilothermic nature and high mortality rate of gizzard shad in low ambient temperatures.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGMENT

None cited.

REFERENCES

1. "Revised Draft Supplement Environmental Statement - Locks and Dam No. 26 (Replacement) - Upper Mississippi River Basin, Mississippi River - Alton, Illinois." Missouri and Illinois. Vol. 1. U. S. Army Corps of Engineers. St. Louis, Missouri. January 1976.

2. "Screen Impingment Studies at the Wood River - Illinois Power Company - Generating Plant - December 1974 to November 1975." Wapora, Inc., Charleston, Illinois. 5 December 1975.

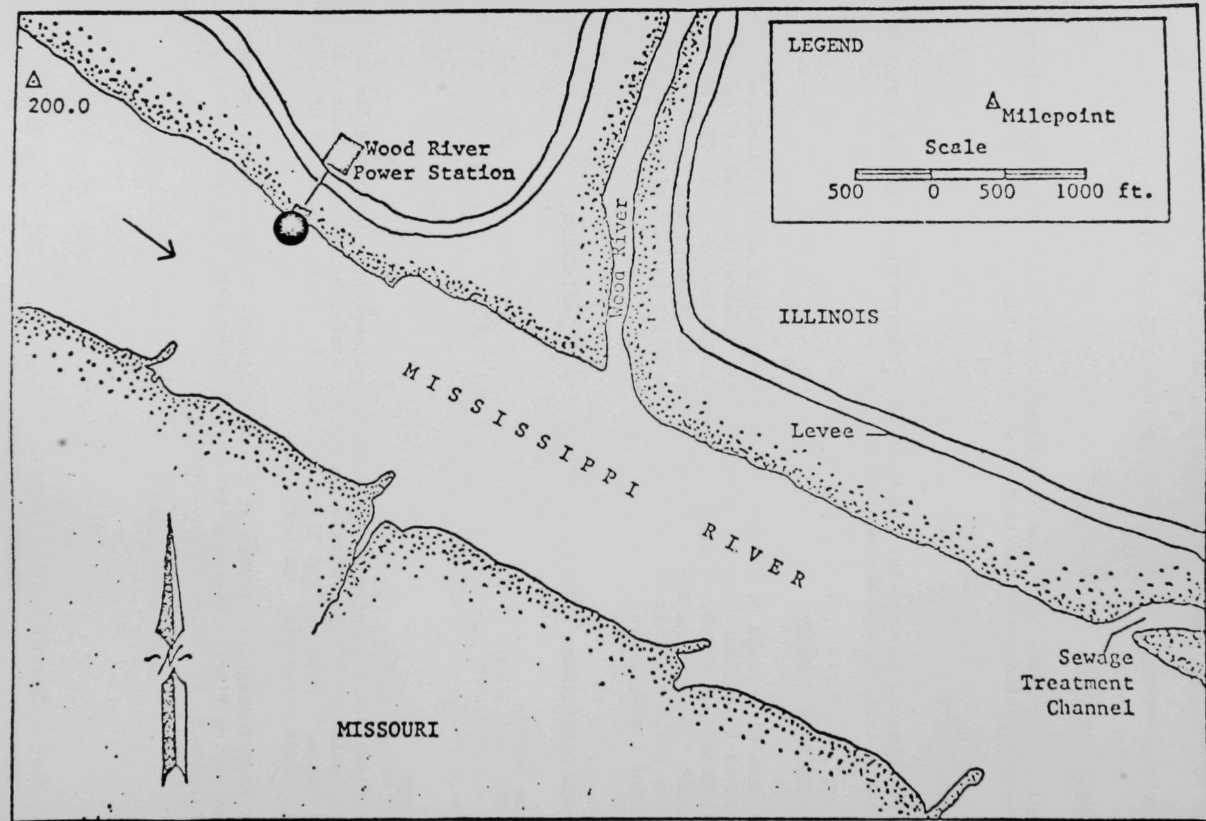


Fig. 1. Station Location.

Table I. Fish Species Found in the Vicinity of the Station

Chestnut lamprey	Highfin carpsucker
Silver lamprey	White sucker
Lake sturgeon	Blue sucker
Shovelnose sturgeon	Creek chubsucker
Paddlefish	Lake chubsucker
Spotted gar	Northern hog sucker
Longnose gar	Smallmouth buffalo
Shortnose gar	Bigmouth buffalo
Bowfin	Black buffalo
American eel	Spotted sucker
Skipjack herring	Silver redhorse
Gizzard shad	Black redhorse
Threadfin shad	Golden redhorse
Goldeye	Shorthead redhorse
Mooneye	Blue catfish
Central mudminnow	Black bullhead
Grass pickerel	Yellow bullhead
Northern pike	Brown bullhead
Stoneroller	Channel catfish
Goldfish	Stonecat
Freshwater drum	Tadpole madtom
Carp	Freckled madtom
Silverjaw minnow	Flathead catfish
Brassy minnow	Burbot
Silvery minnow	Blackstripe topminnow
Speckled chub	Starhead topminnow
Silver chub	Mosquitofish
Hornyhead chub	Brook silverside
Golden shiner	White bass
Emerald shiner	Yellow bass
River shiner	Rock bass
Ghost shiner	Green sunfish
Striped shiner	Pumpkinseed
Bigmouth shiner	Warmouth
Pugnose minnow	Orangespotted sunfish
Spottail shiner	Bluegill
Red shiner	Longear sunfish
Rosyface shiner	Redear sunfish
Silverband shiner	Smallmouth bass
Spotfin shiner	Largemouth bass

Table I. Continued

Sand shiner	White crappie
Redfin shiner	Black crappie
Suckermouth minnow	Mud darter
Southern redbelly dace	Bluntnose darter
Bluntnose minnow	Fantail darter
Fathead minnow	Slough darter
Bullhead minnow	Johnny darter
Creek chub	Orangethroat darter
River carpsucker	Logperch
Quillback	Slenderhead darter
	River darter
	Sauger
	Walleye

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Gizzard Shad	Freshwater Drum	Bluegill	Total
1974	1	1,571	98	114	1,798
1975	11	32,745	3,793	372	37,973

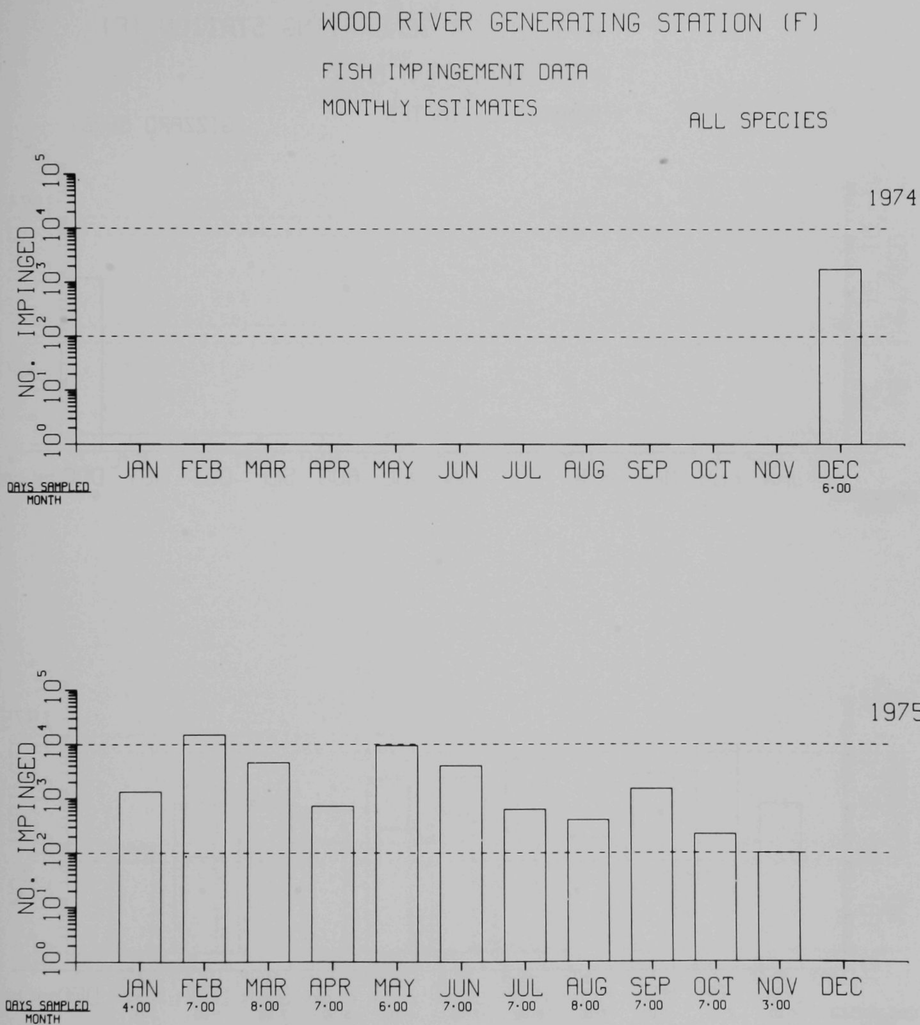


Fig. H1. Impingement Estimates.

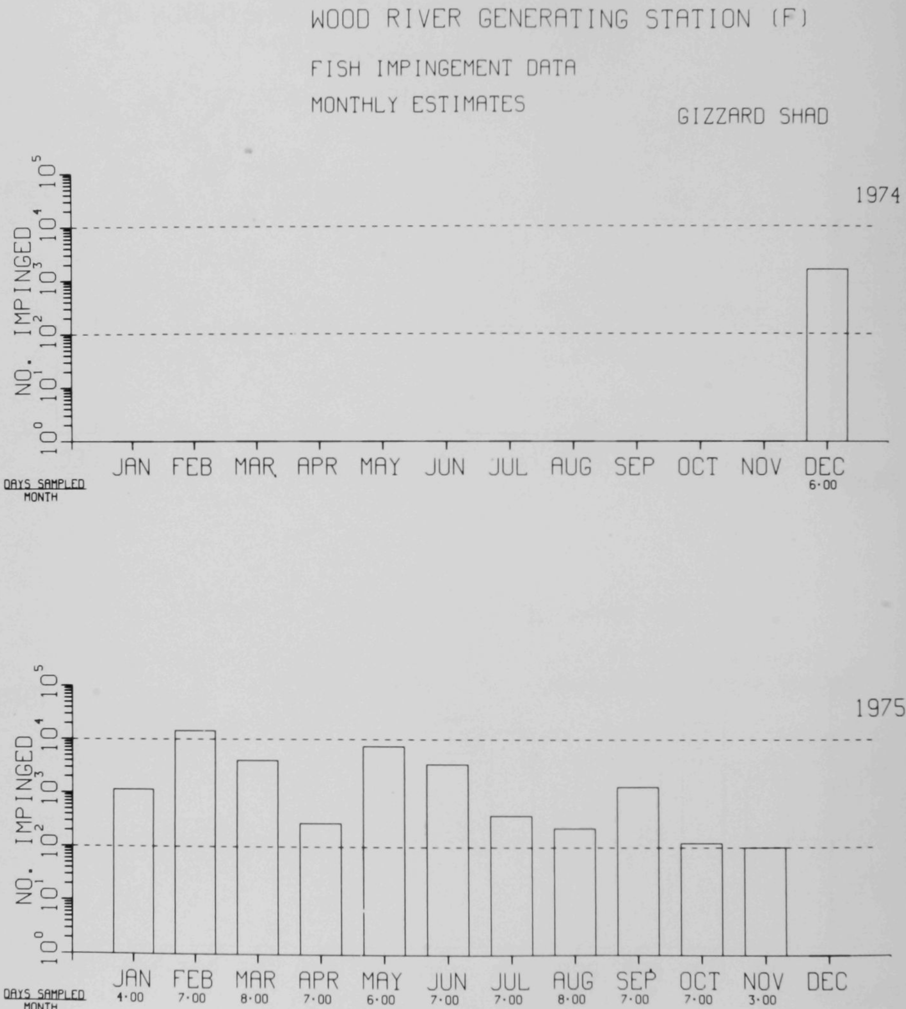


Fig. H2. Impingement Estimates.

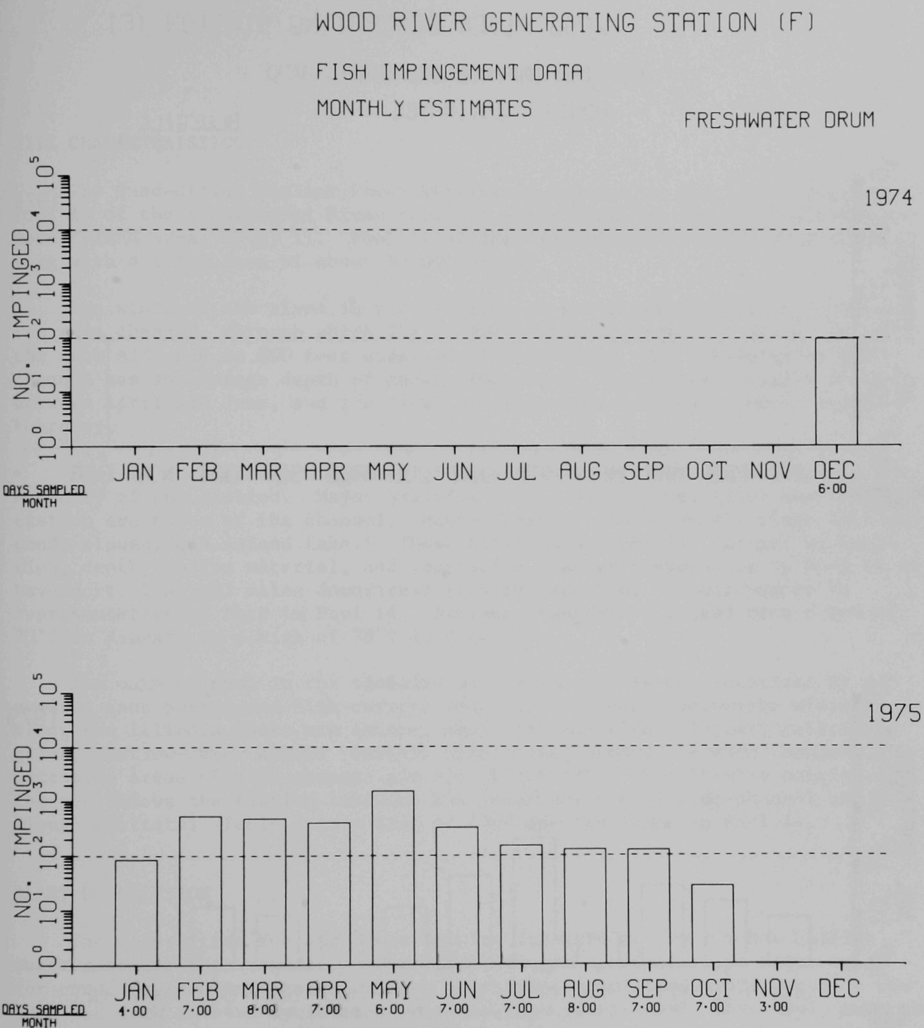


Fig. H3. Impingement Estimates.

WOOD RIVER GENERATING STATION (F)

FISH IMPINGEMENT DATA

MONTHLY ESTIMATES

BLUEGILL

Fig. H4. Impingement Estimates.

QUAD-CITIES NUCLEAR POWER STATION (N)

SITE CHARACTERISTICS

The Quad-Cities Nuclear Power Station is located on the Illinois shore in Pool 14 of the Mississippi River about 21 miles north of the Davenport-Moline-Rock Island area[1] (Fig. 1). Pool 14 of the Mississippi River is 29.2 miles long with a total area of about 12,000 acres.

The width of the river in the vicinity of the station is about 2800 feet. The main channel, through which 75% to 80% of the river water passes, is on the west side and is 800 feet wide and 25 feet deep. The remainder of the channel has an average depth of about eight feet. High flows usually occur between April and June, and low flows usually occur between December and February.

Pool 14 encompasses a variety of aquatic habitats and communities in the vicinity of the station. Major habitats of the Mississippi River near the station are those of the channel, channel border, side channel, river lake and pond, slough, and island lake.[2] These habitats are chiefly defined by location, depth, bottom material, and vegetation. Water temperature in Pool 15 at Davenport, Iowa, 22 miles downstream from the station, is believed to be representative of that in Pool 14. Average temperature ranged from a low of 33°F in January to a high of 78°F in July.

The main channel in the vicinity of the station is characterized by a scoured sand bottom and high current velocity. Directly below the station along the Illinois shore are several small islands with adjacent, relatively quiet, shallow-water areas. Farther downstream, across the main channel, are extensive areas of side-channel and slough habitats. The 16-mile portion of the pool above the station likewise has large amounts of side-channel and slough habitats. Table I is a list of fish species found in Pool 14.

PLANT DESCRIPTION

The Quad-Cities Nuclear Power Station consists of two 809-MWe boiling water reactors that withdraw up to 1,020,000 gpm of Mississippi River water for condenser cooling when operating in the open-cycle mode. The station was operated with an open-cycle condenser-cooling system until 1 May 1974, and discharged heated water into the river through a multi-port diffuser system consisting of two 16-foot-diameter manifolds buried in the river bed with ports installed along the length of the pipes.

A new system of cooling was initiated at the station on 1 May 1974, whereby about 53% of the thermal effluent resulting from station operation is cooled in a spray canal and the remaining 47% is discharged to the river through the south diffuser pipe. The spray canal is about 14,000 feet long, 185 feet wide, and nine feet deep. It is designed to accommodate a flow of about 1,000,000 gpm with both generating units operating. Six lift pumps, each with a capacity of 167,000 gpm, move heated effluent water from the discharge bay into the canal where it is cooled by evaporation, using multiple, floating spray modules. The cooled water returns to the intake bay via an energy-absorbing spillway, following which it is recirculated through the condensers.

INTAKE DESIGN AND OPERATION

Cooling water for the condensers of both units is provided by an intake canal extending into the river. The dimensions of the canal are 235 feet long, 180 feet wide, and 12 feet deep at the point of contact with the river. For once-through operation with either the side-jet or the diffuser, the full-flow requirements of the condensers are obtained directly from the river via this intake canal. For closed-cycle operation of one or both units, the intake canal is partially closed off from the river by control gates, and water recycled from the exit of the spray canal is conducted into the inlet canal where it connects with the forebay of the screenhouse. Each unit can be operated in the open- or closed-cycle mode.

At the maximum cooling-water flow rate of 1,020,000 gpm, the water velocity at the entrance to the intake canal is calculated to be about one fps.[1] This velocity is nearly the same with the spray canal in operation. A floating boom, which extends 33 inches beneath the surface, is provided at the mouth of the canal to deflect floating material.

Between the floating boom and the condensers is a trash rack. The bars of the trash rack are spaced 2-1/2 inches apart and extend from about 20 feet above the waterline to the bottom of the intake canal.

Each condenser pump is further protected by a set of traveling screens with 3/8-inch mesh. These screens rotate at preset time intervals or when activated by a buildup of pressure due to the collection of debris.

IMPINGEMENT SAMPLING

Twice per week, trash baskets were allowed to accumulate fish for a 24-hour period. At the end of the period the contents of the basket were examined. Fish present were identified and counted, and size range, mean size, and total weights were recorded by species.

DATA AVAILABILITY

Impingement data for the Quad-Cities Nuclear Power Station are available for February 1975 through January 1976.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing the total numbers of the three most abundant species as well as all species impinged at the Quad-Cities station. These totals are summarized in Table II.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCES

1. "Operational Environmental Monitoring in the Mississippi River near Quad-Cities Station, February-July 1975." Industrial Bio-Test Laboratories, Inc., Northbrook, Illinois. 3 September 1975.

2. "Final Environmental Statement for Quad-Cities Nuclear Power Station Units 1 and 2." USAEC Directorate of Licensing. Docket Nos. 50-254 and 50-265. September 1972.

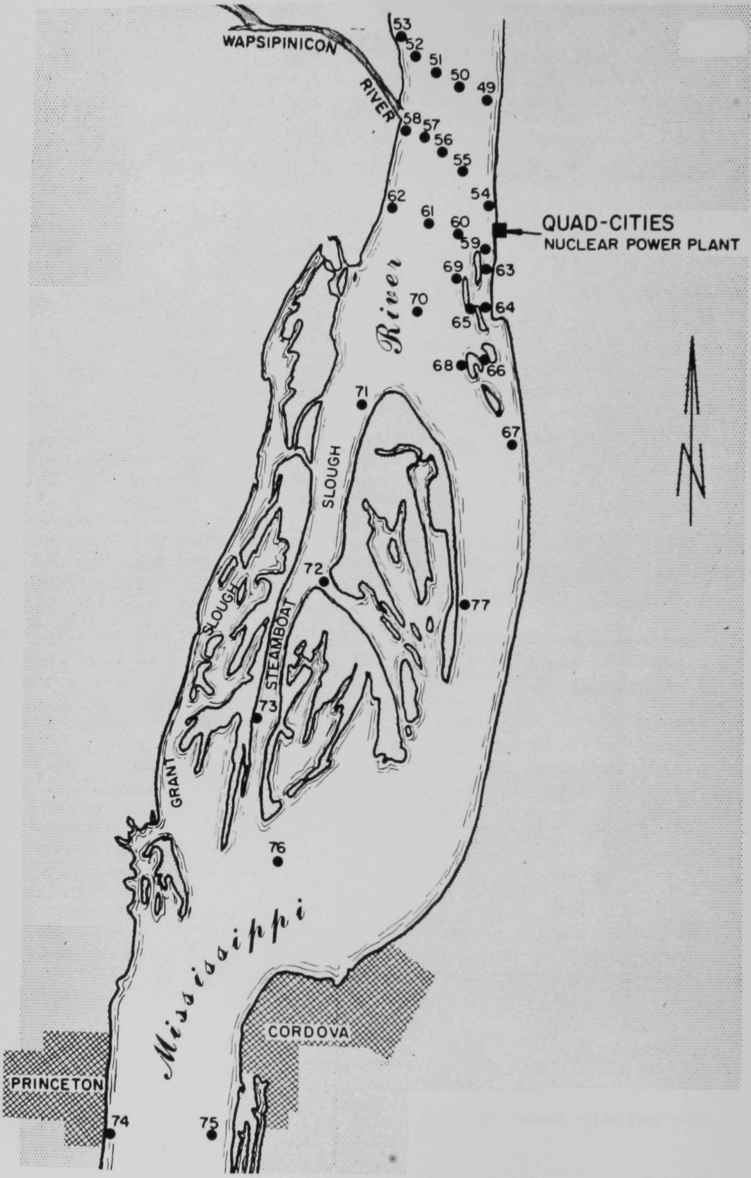


Fig. 1. Plant Location.

Table I. Fish Species of Pool 14

Chestnut lamprey	Spotted sucker
Silver lamprey	Silver redhorse
Shovelnose sturgeon	Shorthead redhorse
Paddlefish	Black bullhead
Longnose gar	Yellow bullhead
Shortnose gar	Channel catfish
Bowfin	Stonecat
Skipjack herring	Tadpole madtom
Gizzard shad	Flathead catfish
Mooneye	Brook silverside
Grass pickerel	White bass
Northern pike	Rock bass
Carp	Warmouth
Silvery minnow	Green sunfish
Speckled chub	Pumpkinseed
Silver chub	Orangespotted sunfish
Golden shiner	Bluegill
Emerald shiner	Smallmouth bass
River shiner	Largemouth bass
Ghost shiner	White crappie
Spottail shiner	Black crappie
Spotfin shiner	Western sand darter
Bluntnose minnow	Mud darter
Fathead minnow	Johnny darter
Bullhead minnow	Yellow perch
River carpsucker	Logperch
Quillback	River darter
White sucker	Sauger
Smallmouth buffalo	Walleye
Bigmouth buffalo	Freshwater drum

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Gizzard Shad	Channel Catfish	Freshwater Drum	Total
1975	11	174,084	2,895	28,956	211,468
1976	1	4,228	8	19	4,278

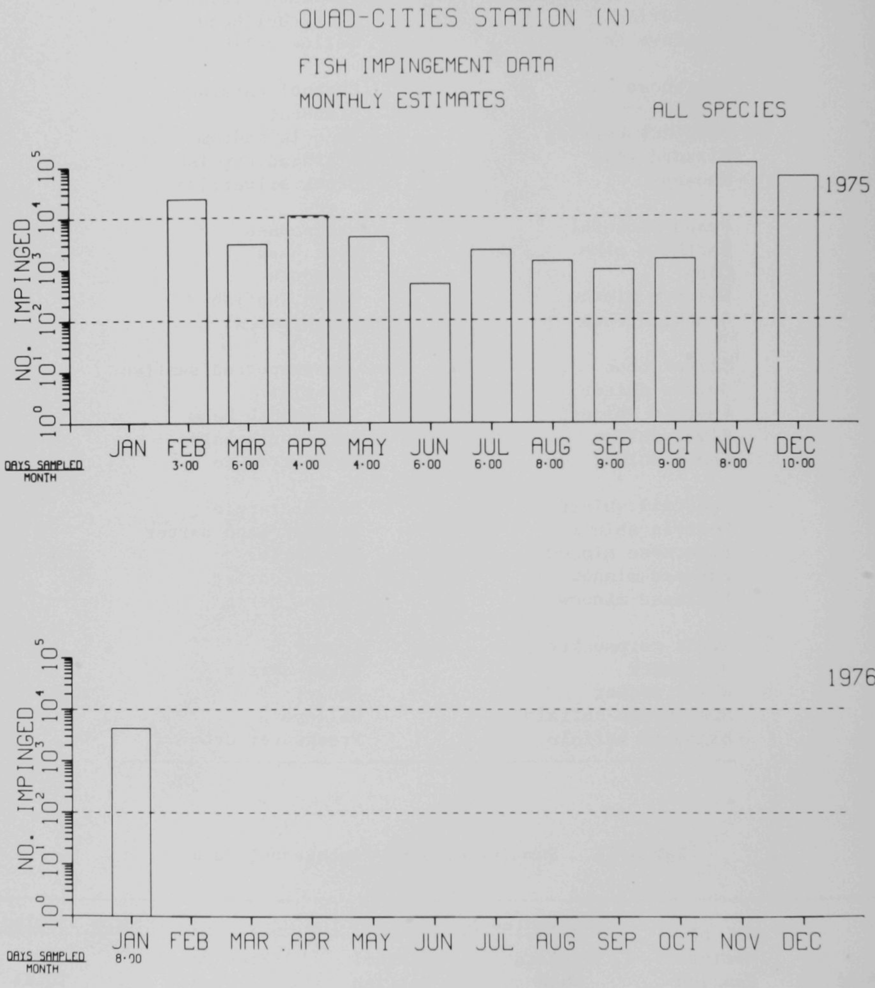


Fig. H1. Impingement Estimates.

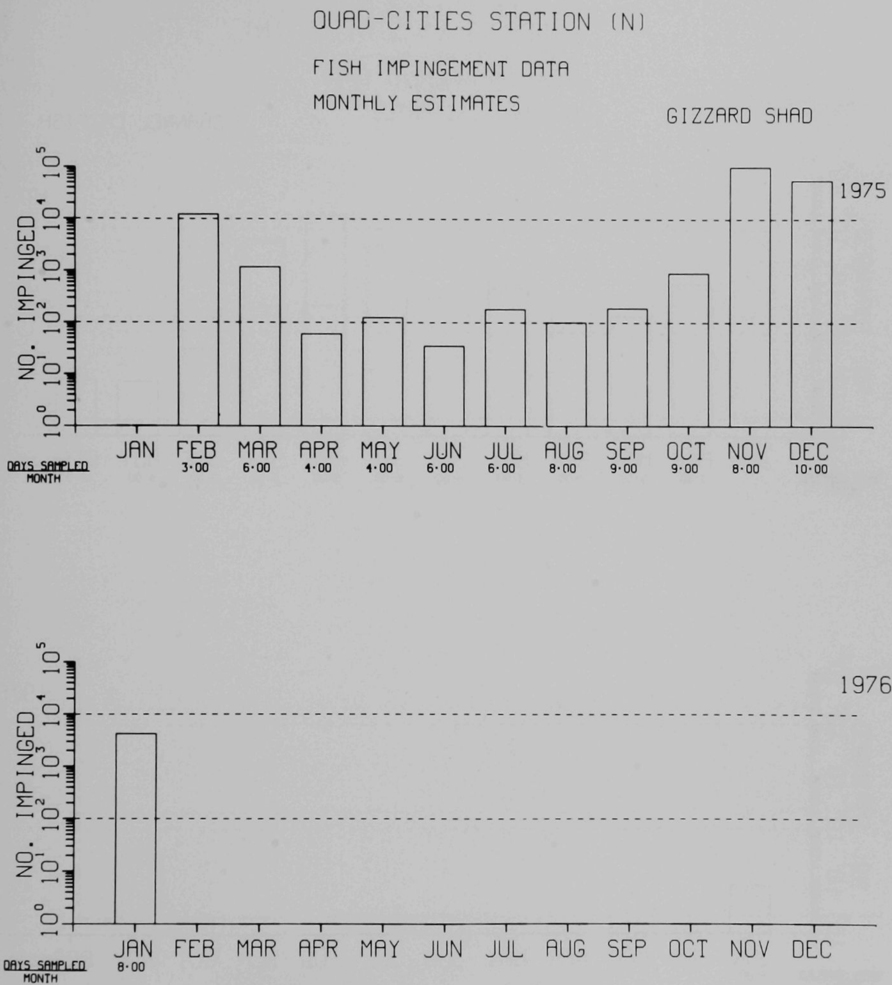


Fig. H2. Impingement Estimates.

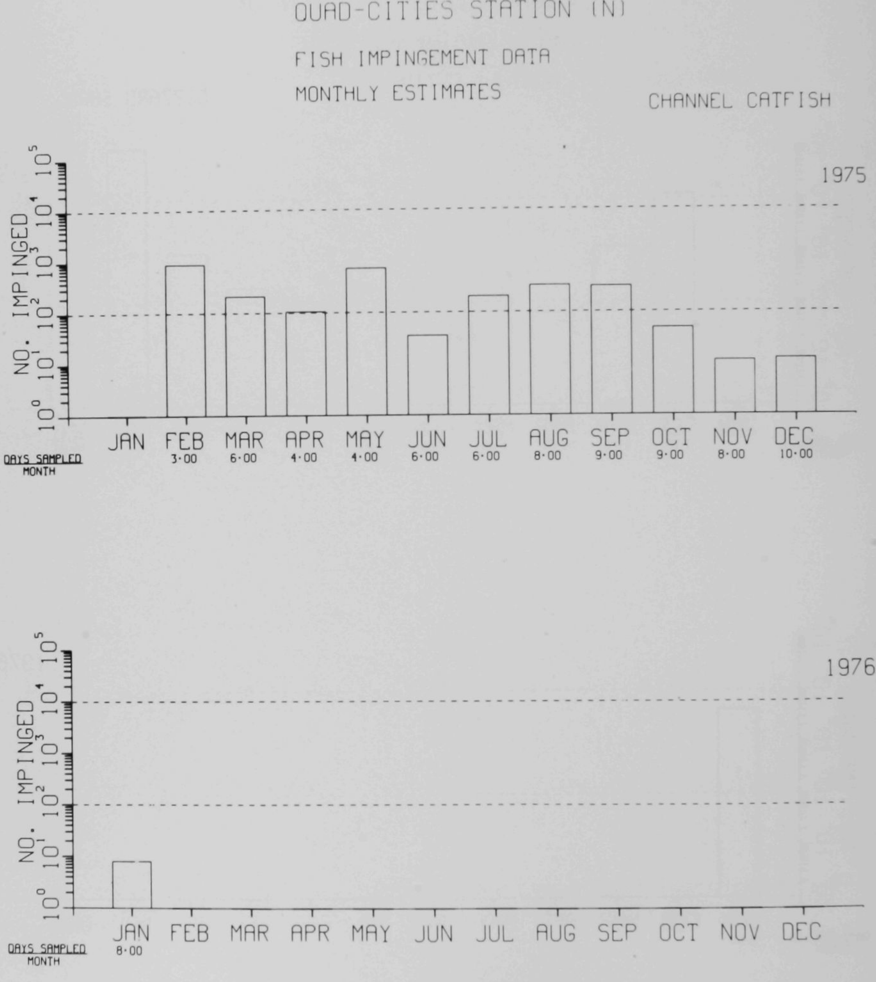


Fig. H3. Impingement Estimates.

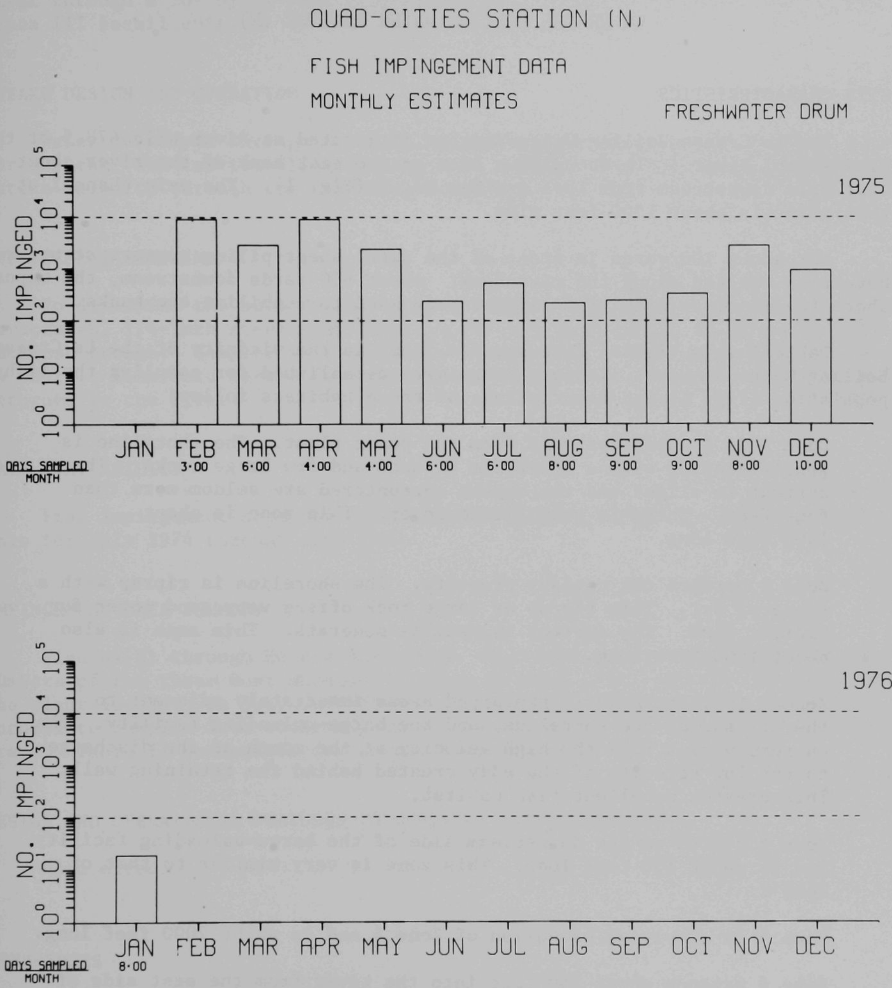


Fig. H4. Impingement Estimates.

LA CROSSE BOILING WATER REACTOR (N)

SITE CHARACTERISTICS

The La Crosse Boiling Water Reactor is located at River Mile 678.5 of the Mississippi River.[1] It occupies a site on the east bank of the river about a half mile downstream from Lock and Dam No. 8 (Fig. 1). The main channel at this point is about 1300 feet wide.

For about 100 yards in front of the site, sheet-piling support structures have been erected along the riverbank. About 800 yards downstream, the exposed shoreline consists mainly of large riprap used to stabilize the banks.

Table I is a list of fish species found in the vicinity of the La Crosse Boiling Water Reactor. Various zones were established for sampling the fish population (Fig. 1) and descriptions of these habitats follow:

> Zone 1 is located upstream from the power plant. The shoreline is gently sloping with a substrate of sand and few large rocks. The current is slight and the depths encountered are seldom more than four feet. There is very little cover. This zone is about 1500 feet long.
>
> Zone 2 borders the company property. The shoreline is riprap with a slope of 3:1. This riprap or large rock offers very good cover for smaller fish. The current is usually moderate. This zone is also about 1500 feet long.
>
> Zone 3 includes heavily riprapped areas immediately adjacent to the discharge, the shoreline, and the barge-unloading facility. The current varies from the high velocity at the mouth of the discharge to the low velocity of the eddy created behind the retaining wall. This creates excellent fish habitat.
>
> Zone 4 starts on the downstream side of the barge-unloading facility and is about 600 feet long. This zone is very similar to that of Zone 2.
>
> Zone 5 is simply an extension of Zone 4 and is about 2000 feet long.
>
> Zone 6 extends about 250 feet into the river from the east side of the closing dam opposite the discharge. The closing dam consists of large rock and extends about 1000 feet downstream. This is a high-current area and is between six and ten feet in depth.

PLANT DESCRIPTION

The La Crosse Boiling Water Reactor is a nuclear plant with a maximum total output of 52 MWe. The plant uses river water to cool the reactor by means of a once-through system. Cooling water is discharged back into the river through a 50- by 21-foot discharge canal, which is common to the nearby Genoa III fossil unit.

INTAKE DESIGN AND OPERATION

Water is pumped through a canal, an intake opening of about 21 by 11 feet, bar screens, and two traveling screens at a maximum flow rate of 64,000 gpm. Intake velocity through the traveling screens is 0.7 fps.[2]

IMPINGEMENT SAMPLING

To determine the numbers and types of fishes impinged on the intake structures, 1/4-inch steel-mesh sampling devices were placed in or under each backwash trough. Samples were collected on a weekly basis for a duration of 24 hours. Fish were sorted from the debris and were measured, identified, and returned to the river.

DATA AVAILABILITY

Fish impingement data for the La Crosse Boiling Water Reactor are available for July 1974 through June 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing the extrapolated total numbers of the three most abundant species as well as all species impinged at the plant intake. In July and October 1974 as well as April 1975 one or more incomplete samples were obtained, which are not accounted for in the histograms. Table II summarizes the totals illustrated in the histograms.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCES

1. "Studies to Determine the Aquatic Ecological Impacts of Thermal Discharges at the Genoa Station." Wapora, Inc., La Crosse, Wisconsin. 27 August 1975.

2. Personal communication with Thomas Steele of Dairyland Power Cooperative. 14 April 1976.

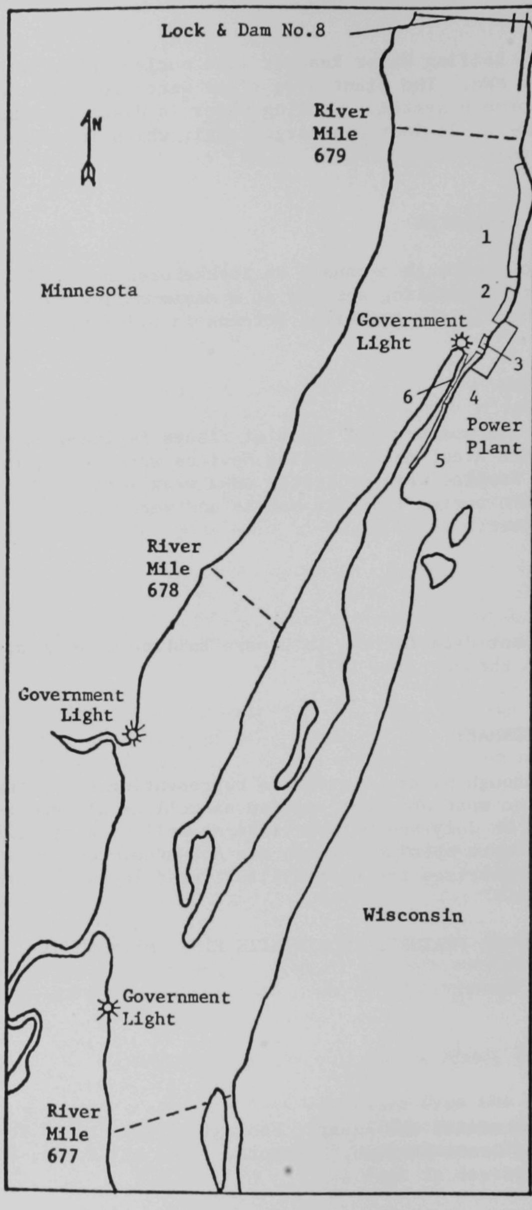


Fig. 1. Reactor Location Showing Numbered Fish-Sampling Zones.

Table I. Fishes Found in the Vicinity of the Reactor

Bluegill	Shortnose gar
Freshwater drum	Quillback
Channel catfish	Spotted sucker
White bass	Pumpkinseed
Emerald shiner	Green sunfish
Gizzard shad	Brook silverside
Tadpole madtom	Blue sucker
Silver chub	Golden redhorse
Logperch	Shovelnose sturgeon
White crappie	Bullhead minnow
Flathead catfish	Trout-perch
Black crappie	Stonecat
Shorthead redhorse	Bigmouth buffalo
Walleye	White sucker
Sauger	River darter
Yellow perch	River shiner
Largemouth bass	Spottail shiner
Bowfin	Brown bullhead
Northern pike	Yellow bullhead
Rock bass	Golden shiner
Longnose gar	Creek chub
Carp	Fathead minnow
Black buffalo	Blacknose dace
Spotfin shiner	Burbot
Slenderhead darter	Black bullhead
Smallmouth bass	Warmouth
River carpsucker	Brown trout
Smallmouth buffalo	Stoneroller
Silver redhorse	Chestnut lamprey
Common shiner	Highfin carpsucker
	Silver lamprey
	Goldfish
	Bluntnose minnow

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Bluegill	Freshwater Drum	White Crappie	Total
1974	6	3,660	1,573	1,139	8,378
1975	6	211	3,204	60	5,225

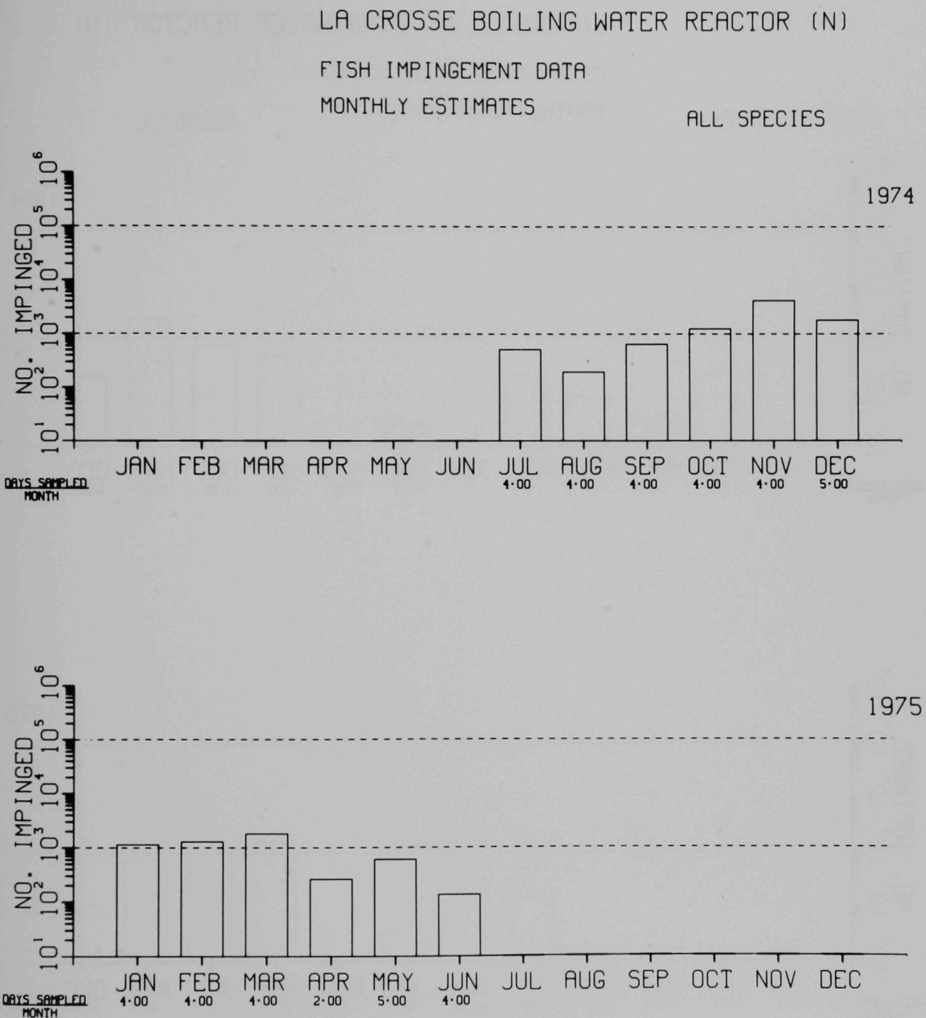


Fig. H1. Impingement Estimates.

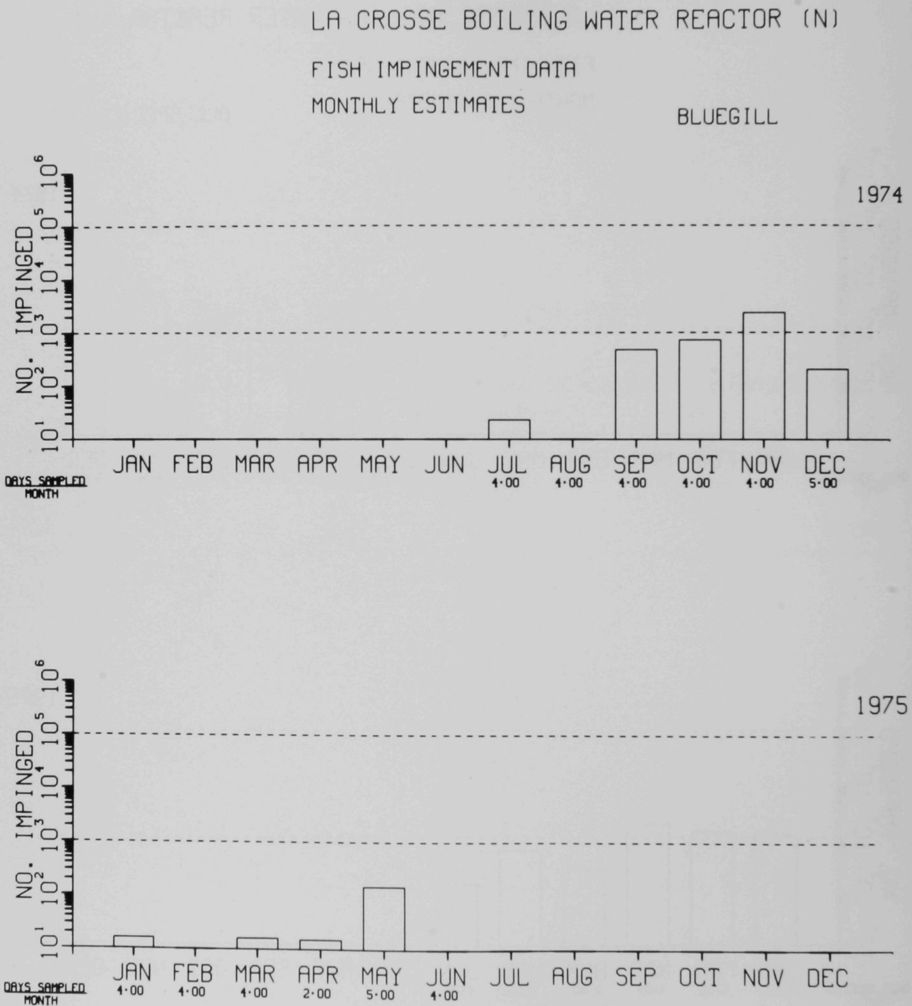


Fig. H2. Impingement Estimates.

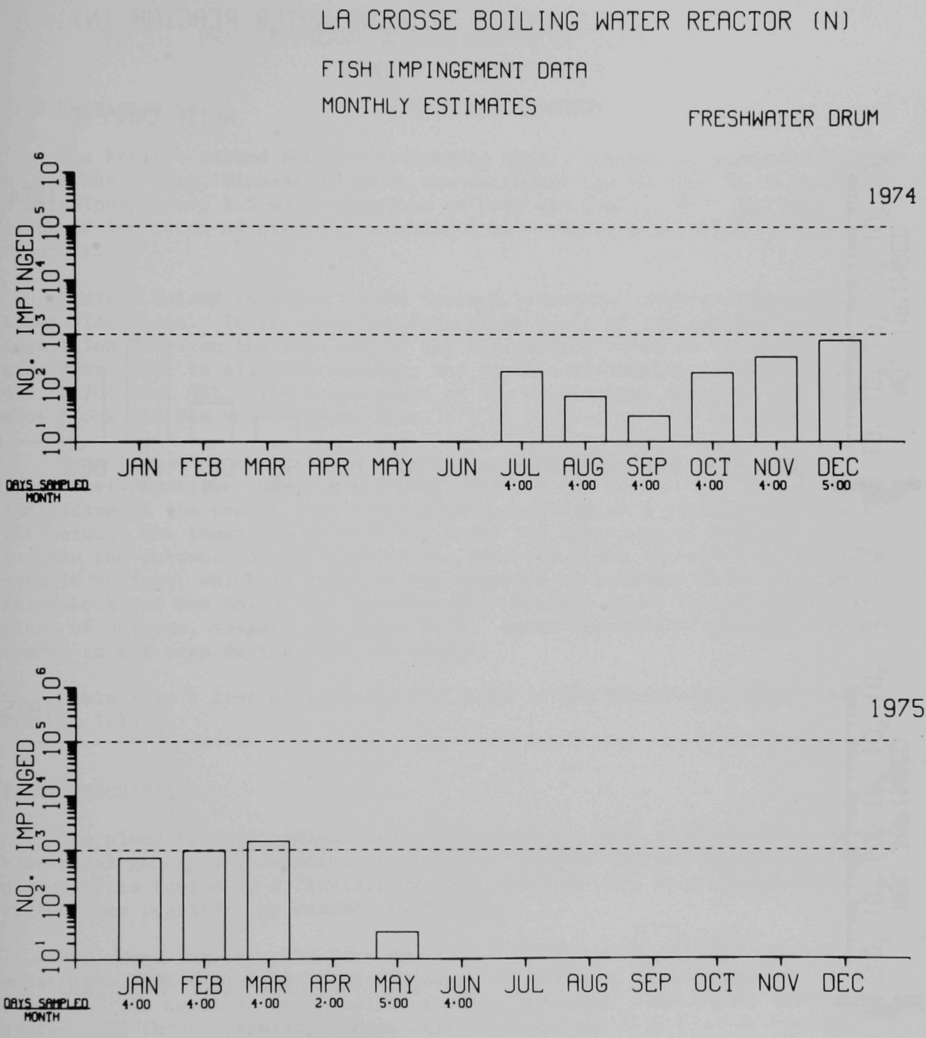


Fig. H3. Impingement Estimates.

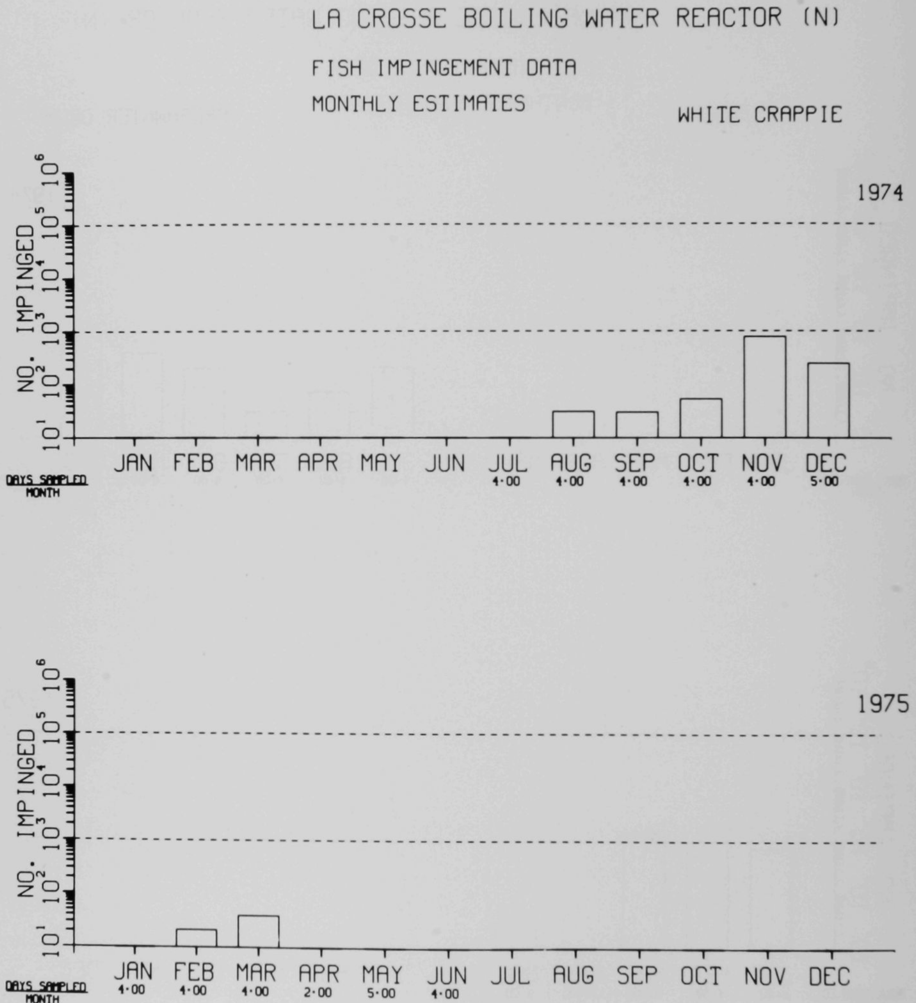


Fig. H4. Impingement Estimates.

PRAIRIE ISLAND NUCLEAR GENERATING PLANT (N)

SITE CHARACTERISTICS

The Prairie Island Nuclear Generating Plant, located in Burnside Township of Goodhue County, Minnesota, is at the southwest end of Pool No. 3 of the Mississippi River, 1.5 miles upstream of Lock and Dam No. 3.[1] The site consists of 560 acres of previously farmed land. The site location is shown in Figure 1.

Prairie Island is a low island terrace associated with the Mississippi River floodplain. It is separated from other parts of the lowland by the Vermillion River on the west and by the Mississippi River on the east. The ground is level to slightly rolling, and surface elevations range from about 675 to 706 feet MSL. The temperature of the Mississippi River in the area above Lock and Dam No. 3 varies from 32°F in January to 84°F in August.

Composition of the fish population varies between Pool Nos. 3 and 4 immediately upstream and downstream of Lock and Dam No. 3. The variation is indicative of the change from a slack-water habitat to a running-water habitat between the lower end of Pool No. 3 and the upper end of Pool No. 4. Because the current is slower above the dam, the river resembles a lake-like aquatic habitat, which is quite stable compared to habitats below the dam. Below Lock and Dam No. 3, the running-water habitat draws larger concentrations of walleye, sauger, and white bass. Large die-offs of gizzard shad are common to the area during fall and winter.

Table I is a list of fish species found in the Mississippi River near Prairie Island.

PLANT DESCRIPTION

The plant has two pressurized water reactors, each of which has a gross electrical generating capacity of 650 MWe. Each of the two condensers (one per unit) is cooled by a flexible system, which is used in a closed-cycle mode except when precluded by weather conditions.

The plant incorporates four mechanical-draft cooling towers that accommodate the full circulating-water flow of the plant. The combination of the river and the cooling towers allows for the design of a condenser cooling system with three operating modes: (1) once-through flow without cooling towers in operation (open cycle), (2) once-through flow with cooling towers in operation to decrease the temperature of system water before it is discharged back to the river (helper cycle), and (3) recirculation of up to 95%

of the condenser-cooling-system water through operating cooling towers (closed cycle). The condenser cooling system is shown in Figure 2. The principle characteristics of the three modes of operation are given in Table II.

INTAKE DESIGN AND OPERATION

The intake canal is a dredged channel about 700 feet long by 110 feet wide. The channel widens as it intrudes into the river, forming an approach canal about 600 feet wide and 1800 feet long, to ensure an unobstructed flow of river water from the mainstream of the river to the screenhouse.

A barrier or skimmer wall prevents large floating objects from entering the intake canal and prevents the warm water of the recycle canal from flowing into the river. The trash rack of the screenhouse consists of vertical 3/8-inch-wide steel bars spaced on three-inch centers. The traveling screens (four parallel units) are made of wire mesh with 3/8-inch-square openings. Debris is removed by an automatic backwash cycle and is sluiced to a collection basket. The velocity of the inlet water at both the trash rack and traveling screens is less than one fps. Design flow rate through the condensers is 610,000 gpm.

IMPINGEMENT SAMPLING

Trash baskets were lifted and emptied at least once per week and generally three times per week. The sampling began and ended with the replacement of trash baskets during midmorning on Wednesdays. With the exception of gizzard shad during the fall and winter periods, all fish were individually counted. Numbers of gizzard shad, when more than 1,000 fish were present, were estimated by counting the number of the fish needed to fill a pail and multiplying by the number of filled pails.

DATA AVAILABILITY

Impingement data are available for January through December 1974.

IMPINGEMENT DATA SUMMARY

About 137,000 gizzard shad and 9400 fish of other species were impinged during the sampling period, for a daily average of about 400 fish. Gizzard shad accounted for about 94% of the total. Impingement numbers of white bass seemed to show a fairly good correlation with plant intake-water appropriation, i.e. as the volume of water increased, so did the number of white bass impinged (Fig. 3).[2]

Figures H1 and H2 are histograms representing total numbers of the four most abundant species as well as all species impinged at Prairie Island. Table III is a summary of the impingement-study results.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

An air-bubble curtain was installed early in 1974 at the Prairie Island Plant. Although a detailed evaluation of this system is presently underway, impingement results from 1974 show the curtain was far from being effective in curtailing fish impingement.

REFERENCES

1. "Final Environmental Statement, Prairie Island Nuclear Generating Plant." USAEC Directorate of Licensing. Docket Nos. 50-282 and 50-306. May 1973.

2. "Environmental Monitoring and Ecological Studies Program for the Prairie Island Nuclear Generating Plant" 1974 Annual Report, Vol. II. Northern States Power Co. 1975.

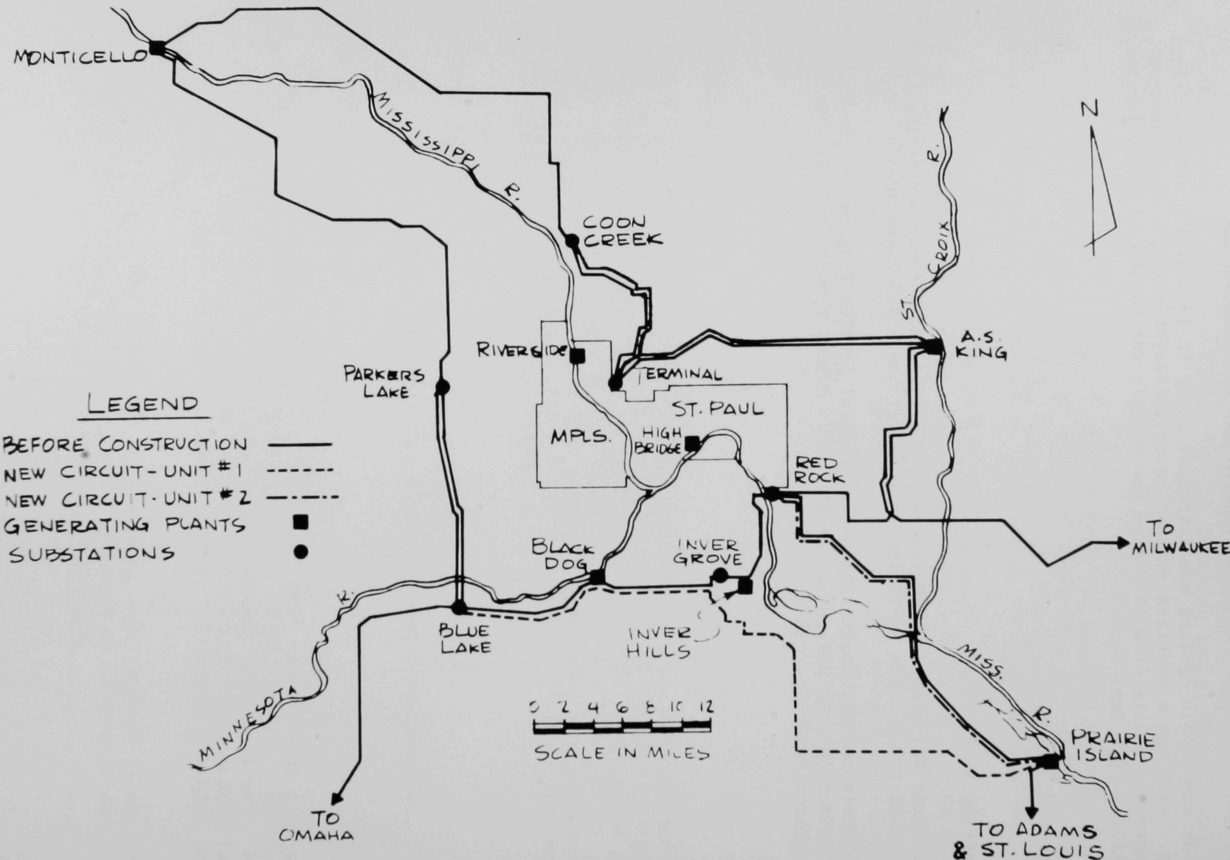


Fig. 1. Site Location.

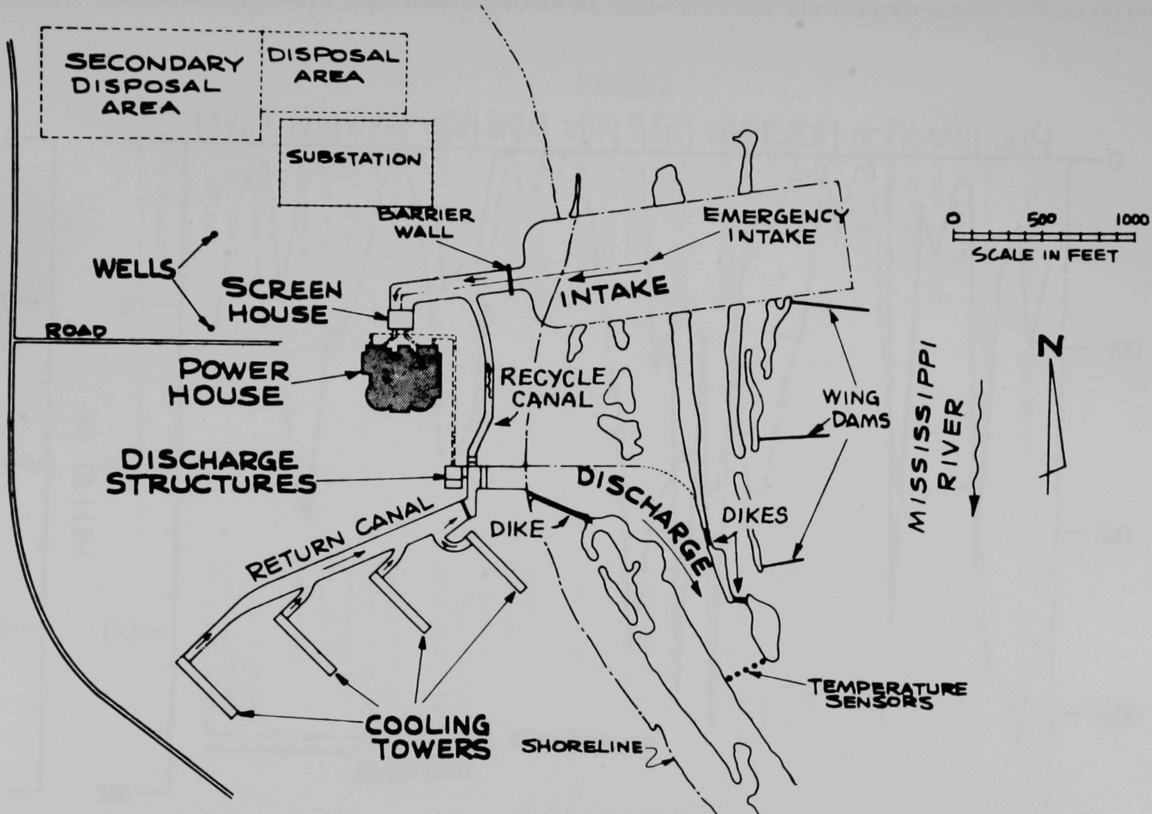


Fig. 2. Condenser Cooling System.

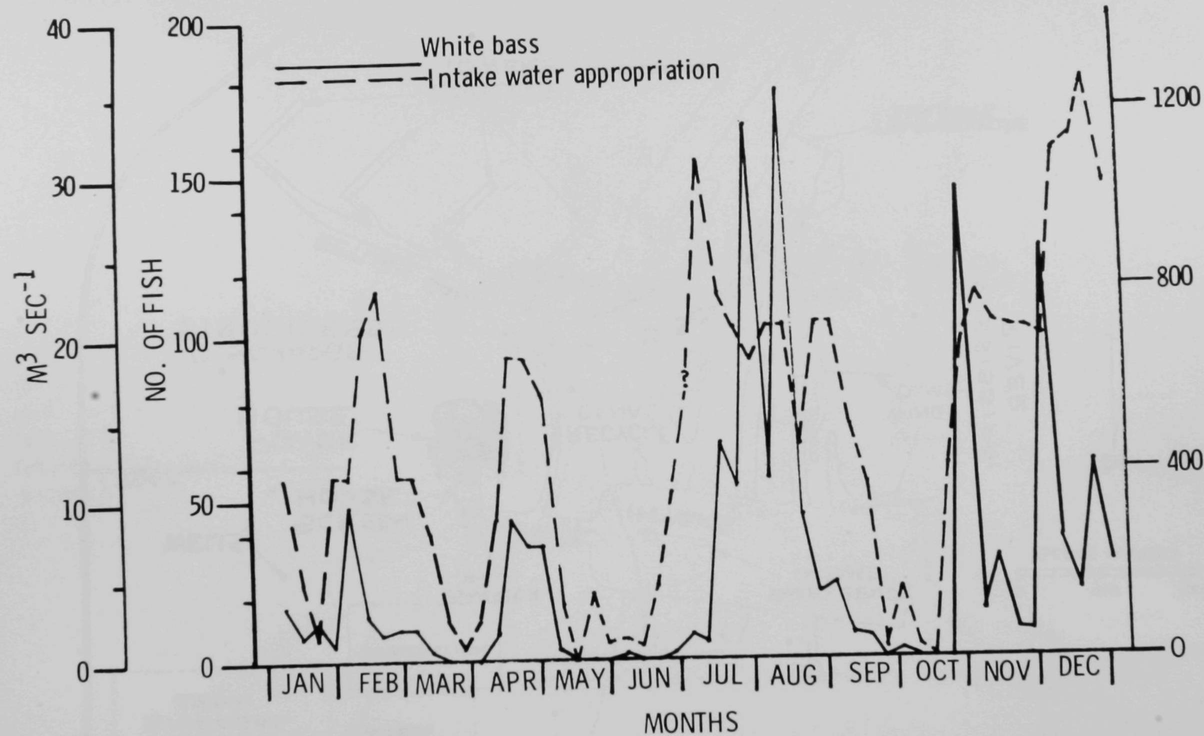


Fig. 3. Comparison of Weekly Impingement Numbers of White Bass and Plant Intake-Water Appropriation.

Table I. Fishes in the Mississippi River near the Site

Silver lamprey	Silvery minnow
Chestnut lamprey	Fathead minnow
Lake sturgeon	Bullhead minnow
Shortnose gar	Bluntnose minnow
Longnose gar	Channel catfish
Bowfin	Black bullhead
Mooneye	Brown bullhead
Goldeye	Yellow bullhead
Gizzard shad	Flathead catfish
Bigmouth buffalo	Tadpole madtom
Smallmouth buffalo	Northern pike
Burbot	American eel
White sucker	Trout-perch
Spotted sucker	White bass
Silver redhorse	Yellow perch
Shorthead redhorse	Sauger
River redhorse	Walleye
Carp	Logperch
Silver chub	Johnny darter
Pugnose minnow	Smallmouth bass
Golden shiner	Largemouth bass
Common shiner	Green sunfish
Emerald shiner	Pumpkinseed
Rosyface shiner	Bluegill
Spotfin shiner	Rock bass
River shiner	White crappie
Spottail shiner	Black crappie
Mimic shiner	Freshwater drum
Blacknose shiner	
Brassy minnow	

Table II. Cooling System Water Flow Rates (gpm)

Mode	Inlet from River	Max. Tower Water Loss to Air	Discharge to River
Open cycle	610,409	0	610,409
Helper cycle	610,409	12,567	597,842
Closed cycle	84,380	17,055	67,325

Table III. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled				
		White Bass	Freshwater Drum	Gizzard Shad	Crappie Spp.	Total
1974	12	1,367	3,047	136,620	1,702	146,061

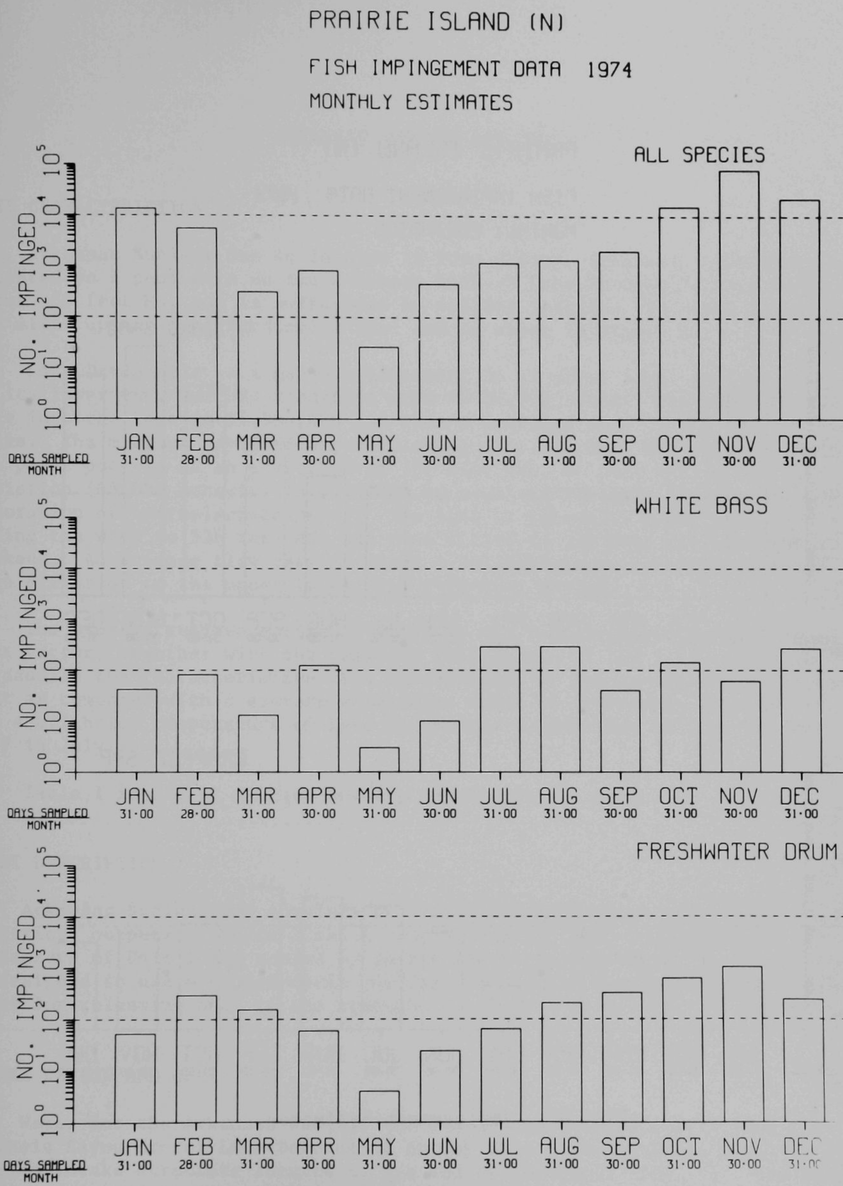


Fig. H1. Impingement Estimates.

PRAIRIE ISLAND (N)

FISH IMPINGEMENT DATA 1974

MONTHLY ESTIMATES

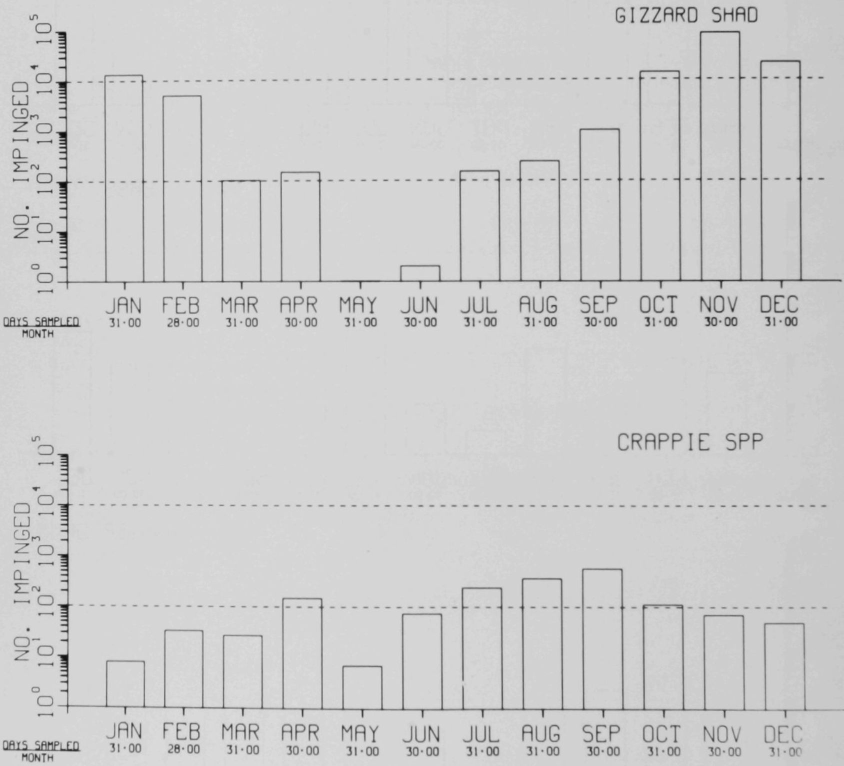


Fig. H2. Impingement Estimates.

ARKANSAS NUCLEAR ONE (N)

SITE CHARACTERISTICS

Arkansas Nuclear One is located in Pope County, Arkansas. The station is situated on a peninsula on the northern bank of Lake Dardanelle in a valley at about 350 feet MSL and is surrounded by rolling terrain. The site is about six miles upstream of Dardanelle Dam[1] and is shown in Figure 1.

Lake Dardanelle is a manmade lake that is 51 miles long, 63 feet deep at its lower end, and has a surface area of 36,600 acres. The average flow rate into the lake is 15,990,000 gpm from a drainage area of 153,703 square miles. The minimum navigation-pool elevation is 336 feet MSL and the top of the power pool is at an elevation of 338 feet MSL, so that only a two-foot variation (65,000 acre-ft) is provided to regulate variable inflows for the generation of hydroelectric power. The lake is generally drawn down slowly during the week to 336 feet MSL and then filled to 338 feet MSL over the weekend. An average flow rate of about 6,700,000 gpm is required to raise the lake elevation to the upper level over a 50-hour period.

The average residence time of water in the lake is about seven days. This factor, together with the relative shallowness of the lake, gives Lake Dardanelle the characteristics of a main-stream, or run-of-the-river, impoundment as compared with a storage reservoir, which is ordinarily much deeper. The equilibrium temperature of Lake Dardanelle ranges from 40°F in January to 85°F in July.

Table I is a list of fish species present in the lake.

PLANT DESCRIPTION

Arkansas Nuclear One consists of two pressurized water reactors. The net electrical outputs of Units 1 and 2 are 820 and 902 MWe, respectively. The condensers of Unit 1 are cooled by once-through cooling water, whereas Unit 2 is designed to use a closed-cycle cooling system with a natural-draft cooling tower for releasing heat to the atmosphere. Unit 2 is not yet in operation.

INTAKE DESIGN AND OPERATION

Water for the Arkansas Nuclear One station is drawn directly from the Illinois Bayou arm of Lake Dardanelle by way of a 4400-foot-long canal to the station intake structure located at the end of the canal (Fig. 2). The intake structure itself is shown in Figure 3. Water is taken in at the rate of 780,000 gpm. Of this amount, Unit 1 uses 766,000 gpm for once-through cooling, and Unit 2 will take 14,000 gpm as makeup water for its cooling tower.

The combined intake for both units will use 49.6% of the minimum flow (1,572,000 gpm) and 4.9% of the average flow (15,993,000 gpm) through the lake.

At the confluence of the intake canal and the reservoir, the approach velocity of the intake water is not greater than 0.3 fps. Water velocity increases to 3.0 fps at one point within the canal because of reduced canal depth and width. Velocities then decline to about 1.5 fps along the remainder of the canal up to the ten forebays (eight for Unit 1 and two for Unit 2). The average velocity through the traveling screens varies from 2.0 to 2.2 fps.

Each of the ten forebays is protected by means of a 10-foot-wide vertical traveling screen constructed of 3/8-inch-square mesh. The rotation rate of the traveling screens is fixed; however, the pressure on the wash system can be adjusted. The traveling screens are automatically cleaned by a high-velocity spray that washes away debris as the screen panels travel past the nozzles. Trash is sluiced through a trough into one of two trash grinders located in front of screens 4 and 5; the water containing the ground material is then discharged in front of screen 2 where it passes through the screens and condensers.

IMPINGEMENT SAMPLING

Impingement sampling at Arkansas Nuclear One has varied somewhat with respect to the number of days per month that samples were taken. Sampling durations varied from eight to 16 to 24 hours per day. Only total numbers of fish impinged were counted from June through the first half of October 1974. Since mid-October 1974 individual fish have been identified to species.

DATA AVAILABILITY

Impingement data are available for June 1974 through July 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing total numbers of the three most abundant species as well as all species impinged at Arkansas Nuclear One Unit 1. These totals are summarized in Table II. As indicated in the table, the totals for individual species in 1974 are based on only 2.5 months of sampling, whereas the total of all species is based on the entire seven-month period.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

Arkansas Power and Light Company installed an air-bubble curtain across the mouth of the intake canal at a depth of about 15 feet. The following conclusions are based on the results of a year's seasonal testing, during which the curtain operation was tested for six weeks per season.[2]

Under present operating conditions the air-bubble curtain does not effectively deter fish from entering the intake canal. Consequently, it does not substantially reduce the impingement of fish on the Unit 1 intake screens. On the contrary, impingement was higher during curtain operation in 13 of 16 tests where statistically significant impingement rates were observed. The utility's report provides further details.[2]

REFERENCES

1. "Final Environmental Statement, Arkansas Nuclear One - Unit 1." USAEC Directorate of Licensing. Docket No. 50-313. February 1973.

2. "Biological Evaluation of Air Curtain at Arkansas Nuclear One - Unit 1." Arkansas Power and Light Company, Little Rock, Arkansas. February 1976.

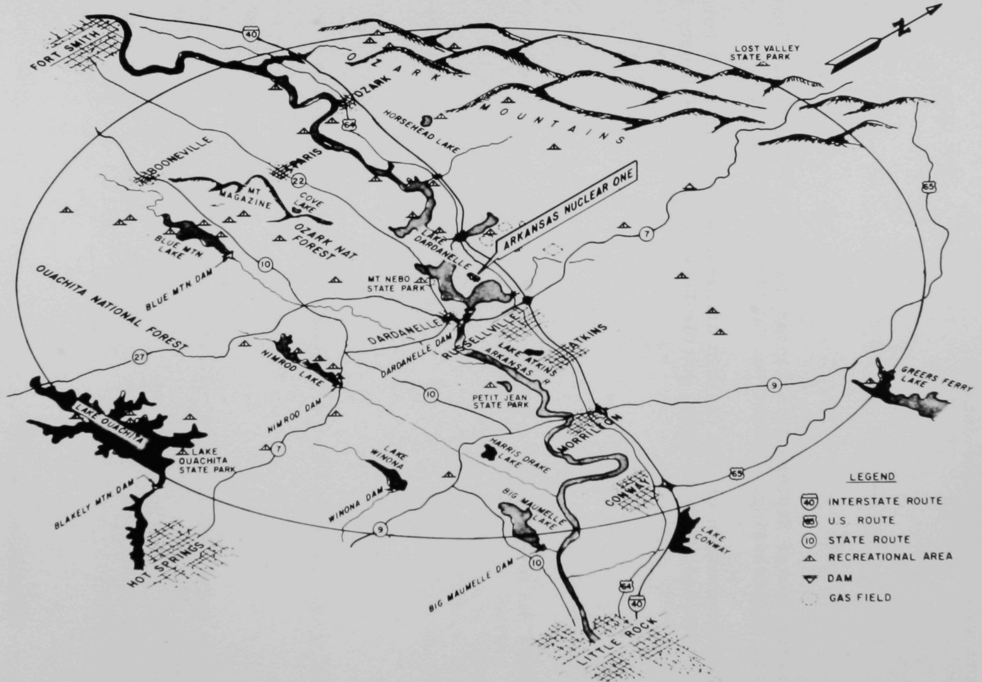
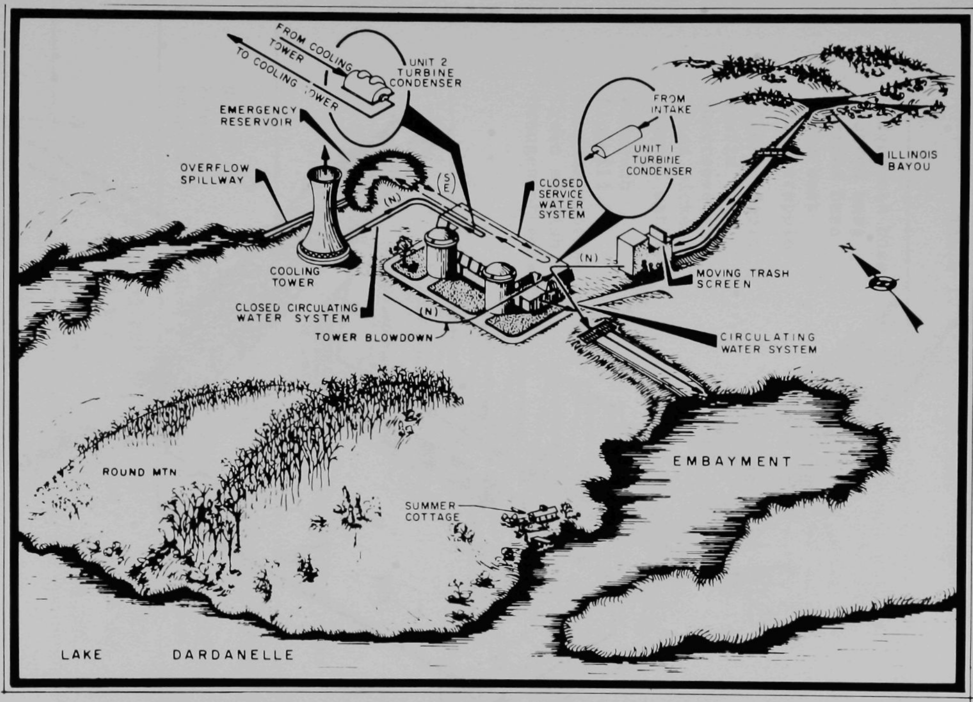


Fig. 1. Area within 50 Miles of the Site.



(N) – NORMAL OPERATION
(S) – SHUTDOWN
(E) – EMERGENCY

Fig. 2. Perspective View Showing Interaction of Heat-Dissipation Systems with Lake Dardanelle.

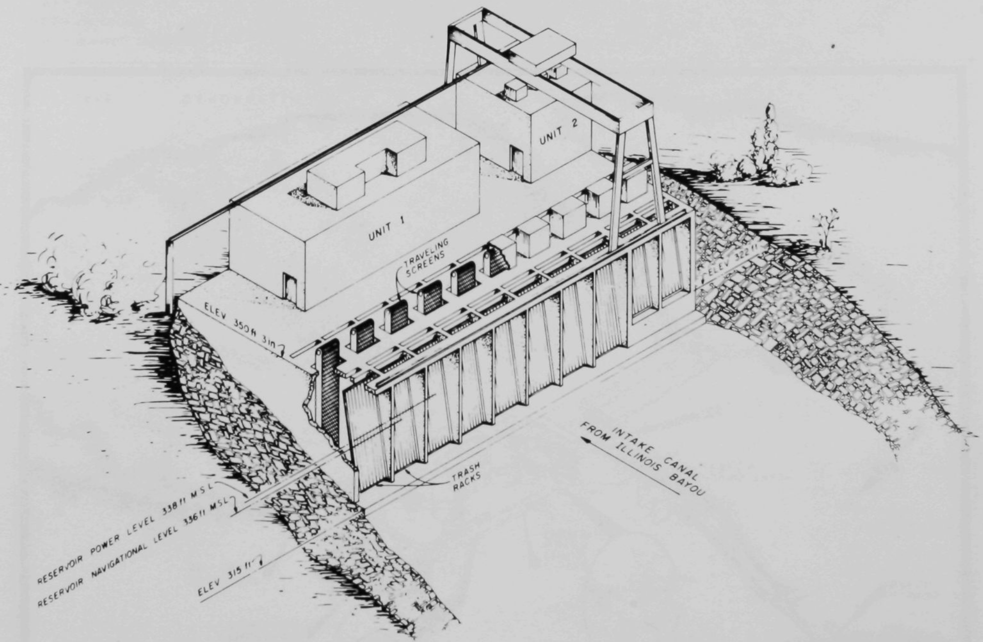


Fig. 3. Intake Structure.

Table I. Fishes in Lake Dardanelle

Largemouth bass	Yellow bullhead
Spotted bass	Black bullhead
Striped bass	Lake chubsucker
White bass	Spotted sucker
White crappie	Freshwater drum
Black crappie	Quillback
Bowfin	Bigmouth buffalo
Shortnose gar	Carp
Grass pickerel	Gizzard shad
Channel catfish	Threadfin shad
Warmouth	Logperch
Bluegill	Pirate perch
Longear sunfish	Longnose gar
Green sunfish	Spotted gar
Orangespotted sunfish	Alligator gar
	Smallmouth buffalo
	Flathead catfish

Table II. Summary of Fish Impingement Data

		Estimated No. of Fish Impinged during Months Sampled			
Year	No. of Months Sampled	Threadfin Shad	Gizzard Shad	Freshwater Drum	Total
1974	7	15,155,802 (2.5 mo)	692,688 (2.5 mo)	12,326 (2.5 mo)	16,031,932 (7 mo)
1975	7	15,239,389	863,096	59,022	15,866,532

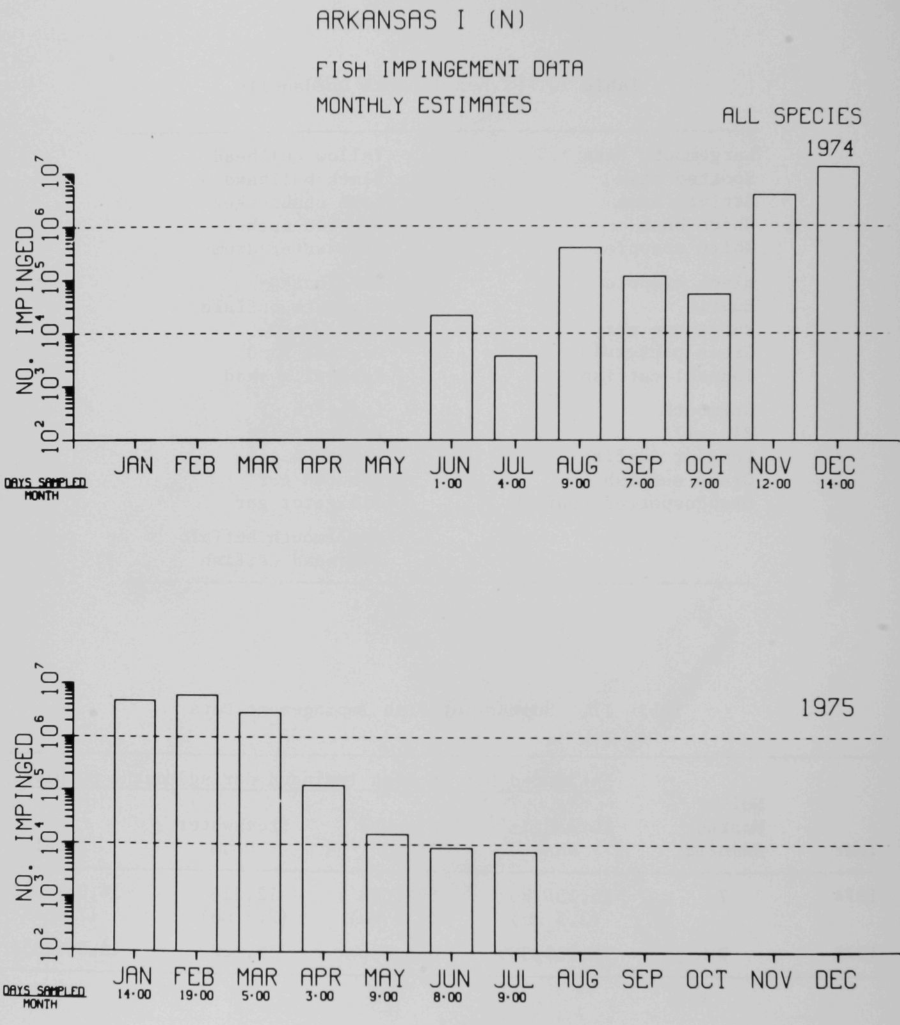


Fig. H1. Impingement Estimates.

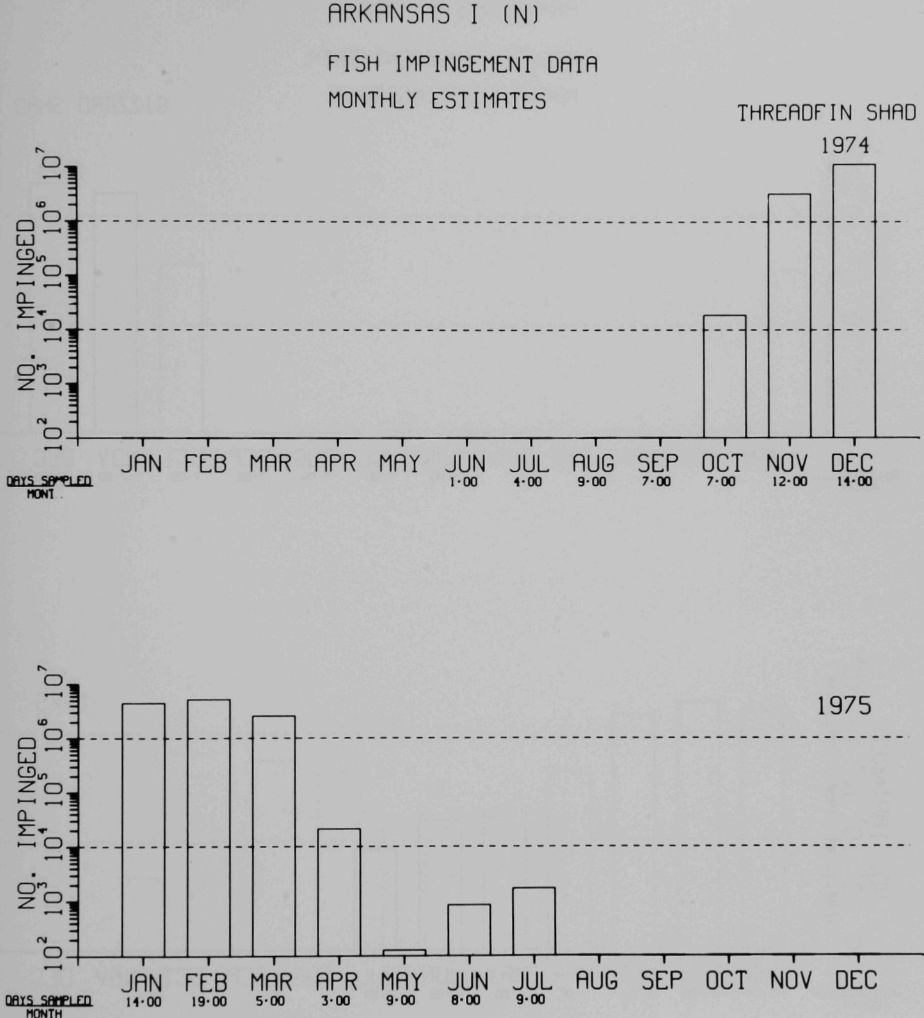


Fig. H2. Impingement Estimates.

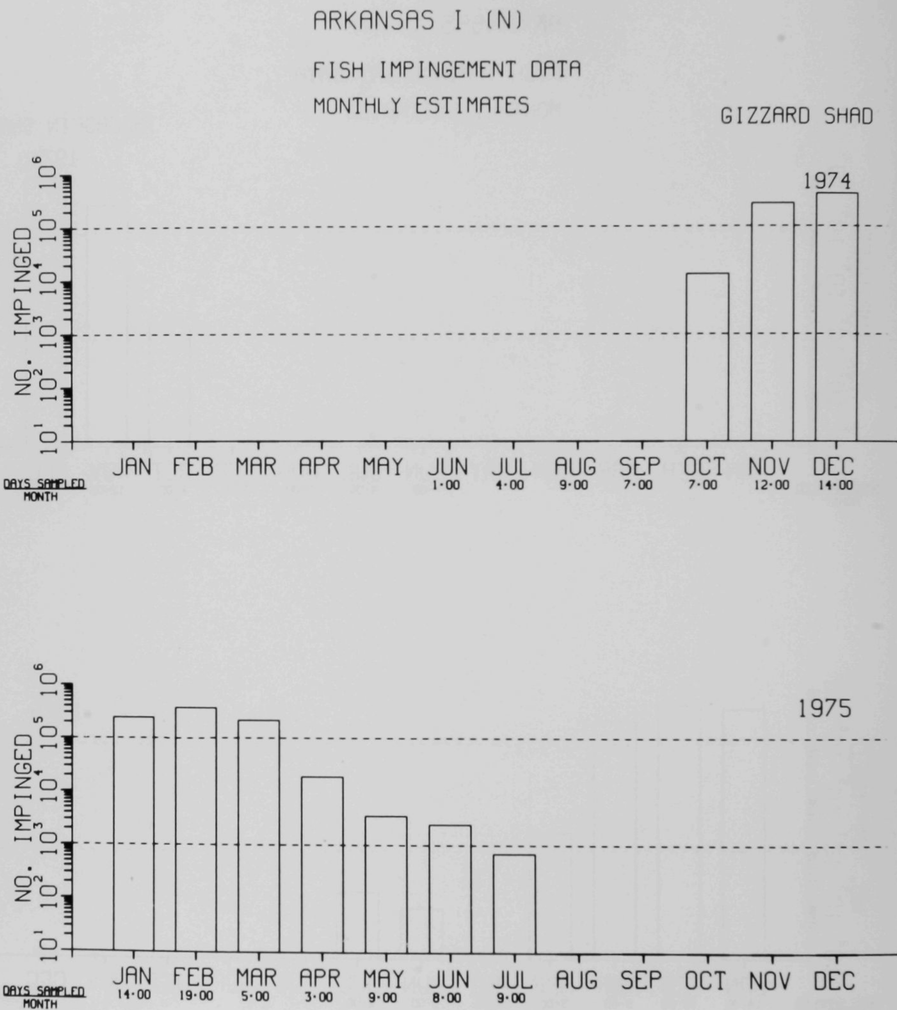


Fig. H3. Impingement Estimates.

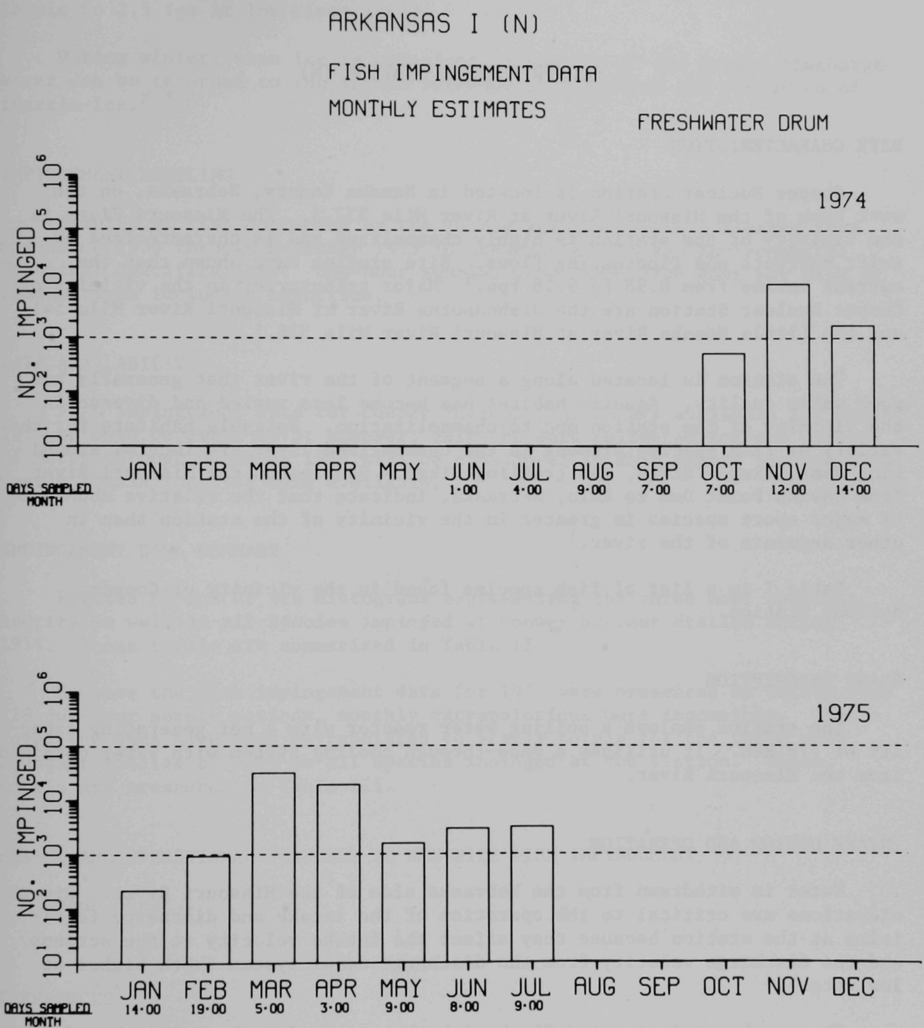


Fig. H4. Impingement Estimates.

COOPER NUCLEAR STATION (N)

SITE CHARACTERISTICS

Cooper Nuclear Station is located in Nemaha County, Nebraska, on the west bank of the Missouri River at River Mile 532.5. The Missouri River in the vicinity of the station is highly channelized and is characterized by swift currents and fluctuating flows. Site studies have shown that the current varies from 0.98 to 9.18 fps.[1] Major tributaries in the vicinity of Cooper Nuclear Station are the Nishnabotna River at Missouri River Mile 541 and the Little Nemaha River at Missouri River Mile 528.5.

The station is located along a segment of the river that generally has good water quality. Aquatic habitat has become less varied and diverse in the vicinity of the station due to channelization. Suitable habitats for the variety of fish species present in the channelized river are located around wing dams, finger dikes, and trailing dikes. Studies on the Missouri River from Gavins Point Dam to Rulo, Nebraska, indicate that the relative abundance of major sport species is greater in the vicinity of the station than in other segments of the river.[1]

Table I is a list of fish species found in the vicinity of Cooper Nuclear Station.

PLANT DESCRIPTION

The station employs a boiling water reactor with a net generating capacity of 778 MWe. It utilizes a once-through cooling system with water obtained from the Missouri River.

INTAKE DESIGN AND OPERATION

Water is withdrawn from the Nebraska side of the Missouri River. River elevations are critical to the operation of the intake and discharge facilities at the station because they affect the intake velocity to the screens and the discharge velocity from the discharge-canal system (both higher at low water).

The pumphouse is located flush with the protective-channel works of the Corps of Engineers. A guidewall designed to reduce the amount of sediment being taken into the plant is located parallel to the front of the pumphouse (Fig. 1). Cooling water enters the pumphouse from the main channel of the river through an outer trash rack with 2.5-inch openings. Within the pumphouse, debris is removed by a series of traveling screens having 3/8-inch mesh openings that are pressure washed. Debris goes into a common trough. Four circulating-water pumps have a maximum pumping capacity of 651,000 gpm. Estimated velocities at the intake screens vary from 1.3 fps at high river levels to 2.5 fps at low river levels.

During winter, when ice is prevalent, a portion of the heated discharge water can be returned to the intake screenwell to control the formation of frazzle ice.[2]

IMPINGEMENT SAMPLING

Samples of fish entrapped by the intake structure were collected from mid-March 1974 through December 1975 in accordance with the Environmental Technical Specifications. One-hour samples were taken five days per week at random times including nighttime.

DATA AVAILABILITY

Fish impingement data for Cooper Nuclear Station are available for March 1974 through December 1975; however, only the data collected for the period of March through December 1974 will be considered in this report because only yearly totals for 1975 were available.

IMPINGEMENT DATA SUMMARY

Figures H1 and H2 are histograms representing the three most abundant species as well as all species impinged at Cooper Nuclear Station during 1974. These totals are summarized in Table II.

Because the fish impingement data for 1975 were presented as totals over 129 one-hour sample periods, monthly extrapolations were impossible. Therefore, the data have been extrapolated to yearly totals for the three most abundant species as well as all species impinged at the station. These totals are presented in Table III.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCES

1. "The Evaluation of Thermal Effects in the Missouri River near Cooper Nuclear Station - 316(a)&(b) Demonstration." Nalco Environmental Sciences, Northbrook, Illinois. 23 October 1975.

2. "Final Environmental Statement, Cooper Nuclear Station." USAEC Directorate of Licensing. Docket No. 50-298. February 1973.

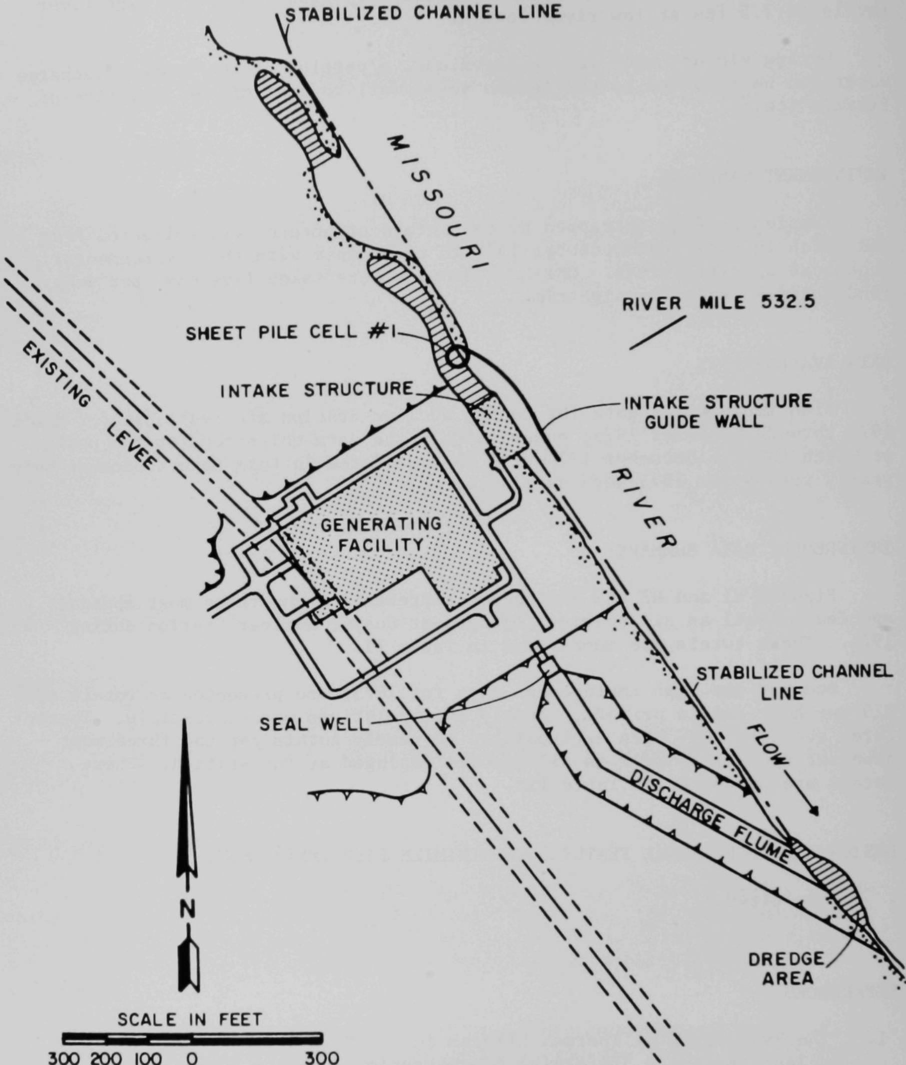


Fig. 1. Station Layout Showing Intake and Discharge.

Table I. Fishes Found in the Vicinity of the Station

Shovelnose sturgeon	Bigmouth buffalo
Paddlefish	Golden redhorse
Longnose gar	Shorthead redhorse
Shortnose gar	Black bullhead
Bowfin	Yellow bullhead
American eel	Brown bullhead
Skipjack herring	Channel catfish
Gizzard shad	Stonecat
Goldeye	Flathead catfish
Sturgeon chub	Burbot
Carp	Plains killifish
Silvery minnow	White perch
Plains minnow	White bass
Speckled chub	Green sunfish
Northern pike	Pumpkinseed
Flathead chub	Orangespotted sunfish
Sicklefin chub	Bluegill
Silver chub	Smallmouth bass
Emerald shiner	Spotted bass
River shiner	Largemouth bass
Red shiner	White crappie
Sand shiner	Black crappie
Suckermouth minnow	Iowa darter
Fathead minnow	Johnny darter
Creek chub	Yellow perch
River carpsucker	Logperch
Quillback	Sauger
White sucker	Walleye
Blue sucker	Freshwater drum
Smallmouth buffalo	

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		River Carpsucker	Gizzard Shad	Freshwater Drum	Total
1974	9	5,452	108,898	34,625	162,519

Table III. Extrapolated Fish Impingement Data for 1975

Data Type	River Carpsucker	Gizzard Shad	Freshwater Drum	Total
Number collected	176	221	110	676
Extrapolated total	11,952	15,007	7,470	45,905

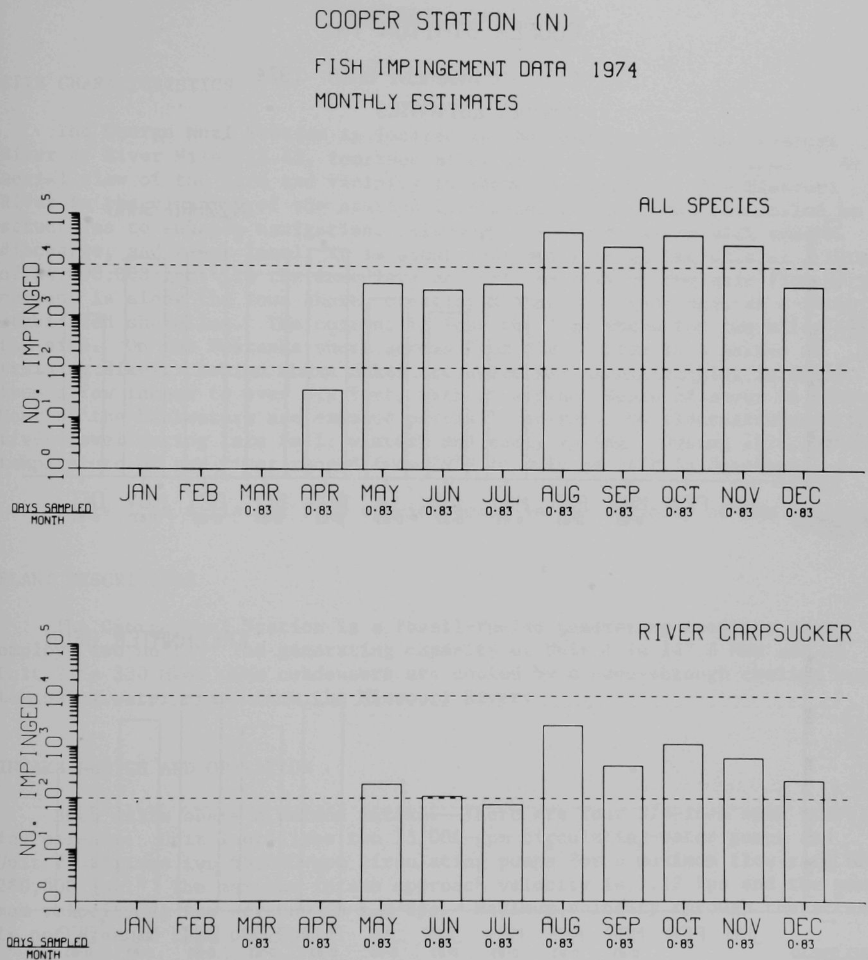


Fig. H1. Impingement Estimates.

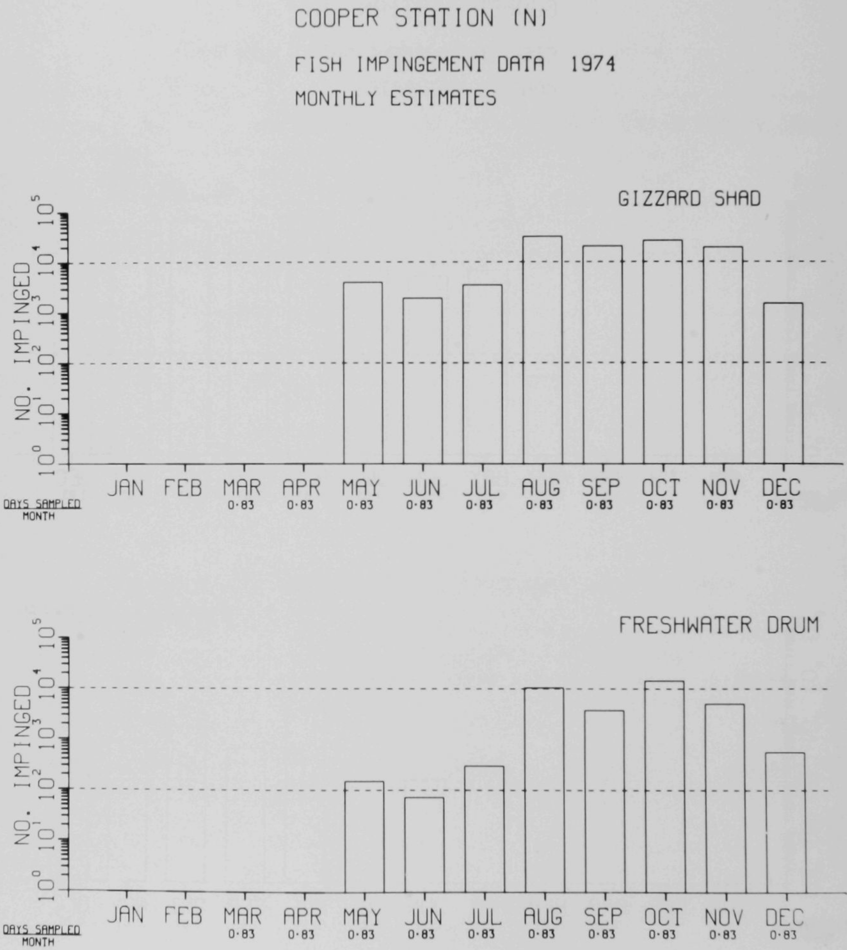


Fig. H2. Impingement Estimates.

GEORGE NEAL STATION (F)

SITE CHARACTERISTICS

The George Neal Station is located on the east bank of the Missouri River at River Mile 718.43, fourteen miles south of Sioux City, Iowa.[1] An aerial view of the site and vicinity is shown in Figure 1. The Missouri River in the vicinity of the station is channelized and well controlled by structures to enhance navigation. Although its width varies with season, discharge, and river level, it is about 750 feet wide at the site at a flow of 14,000,000 gpm. In the immediate area of the station the main flow of the current is along the Iowa shore, creating a strong current against a rock-stabilized shoreline. The current follows the Iowa shore for two miles below the site. On the Nebraska shore across from the station is a series of training dikes. Behind these dikes are quiet backwaters ranging in depth from a few inches to over six feet, with an average depth of about 18 inches. Most of the backwaters are exposed partially or fully by fluctuations of the river level during late fall, winter, and early spring. During 1974, water temperature of the river ranged from 79°F in July to 31°F in December.

Table I is a list of fish species found in the vicinity of the station.

PLANT DESCRIPTION

The George Neal Station is a fossil-fueled generating facility that employs two units. The generating capacity of Unit 1 is 147.5 MWe and of Unit 2 is 330 MWe. The condensers are cooled by a once-through cooling system using water drawn from the Missouri River.

INTAKE DESIGN AND OPERATION

Both units share a common intake. There are four 3/8-inch mesh traveling screens. Unit 1 utilizes two 75,000-gpm circulating-water pumps and Unit 2 utilizes two 65,000-gpm circulating pumps for a maximum flow rate of 280,000 gpm.[2] The maximum intake approach velocity is 1.12 fps and the maximum velocity at the screens is 1.0 fps. Maximum velocity through the screens is not greater than one fps.

IMPINGEMENT SAMPLING

Impingement studies at the George Neal Station were initiated in February 1974 and conducted over a year-long period. Fish were collected at three of four intake chambers for 16 hours per week (9.5% of the time) from February to May 1974 and 24 hours per week (14.3% of the time) from June 1974 to February 1975.

DATA AVAILABILITY

Impingement data for the George Neal Station are available for February 1974 through February 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H5 are histograms representing the total numbers of the four most abundant species as well as all species impinged at the George Neal Station. These totals are an estimate of total projected impingement[1] and are summarized in Table II.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCES

1. Jane Hey and Kenneth Baldwin. "Aquatic Ecology Study (Pre-operational Survey, Unit III) of the Missouri River near the George Neal Station - June 1974-December 1975." Briar Cliff College Print Shop, Sioux City, Iowa. January 1976.

2. Personal communication with Greg Axelsen of Iowa Public Service Company. 12 May 1976.

Fig. 1. Aerial View of Site and Vicinity.

Table I. Fish Species Found near the Station

Shortnose gar	Shorthead redhorse
Longnose gar	Bigmouth buffalo
Pallid sturgeon	Smallmouth buffalo
Shovelnose sturgeon	Channel catfish
Gizzard shad	Black bullhead
Skipjack herring	Flathead catfish
Goldeye	Stonecat
Northern pike	Burbot
Carp	White bass
Flathead chub	Largemouth bass
River carpsucker	Green sunfish
Freshwater drum	Bluegill
Bullhead minnow	Orangespotted sunfish
White sucker	White crappie
Blue sucker	Black crappie
	Johnny darter
	Yellow perch
	Sauger
	Walleye

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled				
		Gizzard Shad	Freshwater Drum	Bluegill	Channel Catfish	Total
1974	11	3,080	1,844	1,417	551	8,896
1975	2	156	308	0	224	868

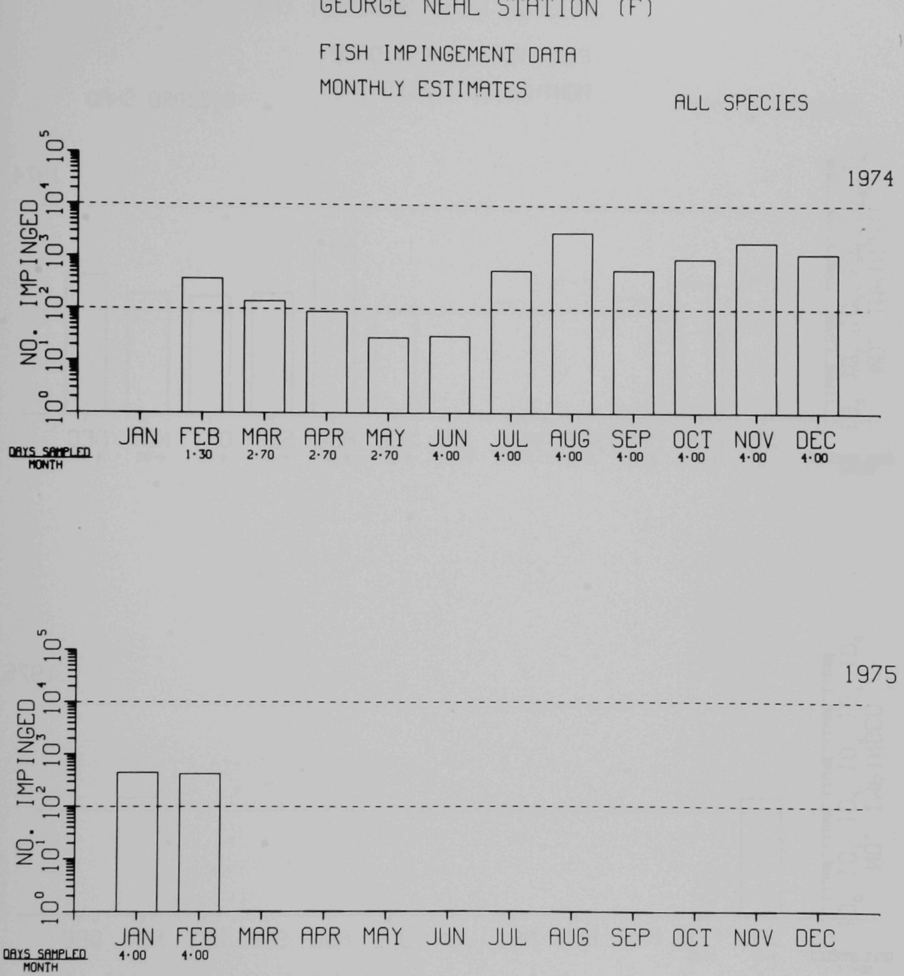


Fig. H1. Impingement Estimates.

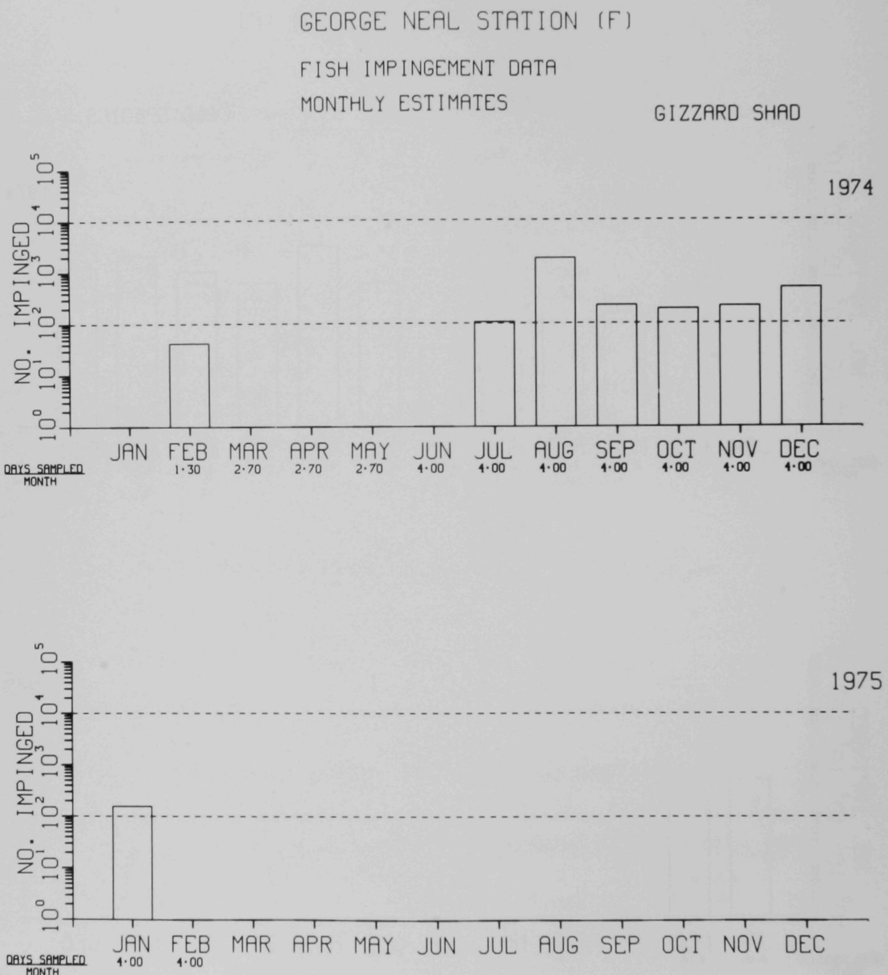


Fig. H2. Impingement Estimates.

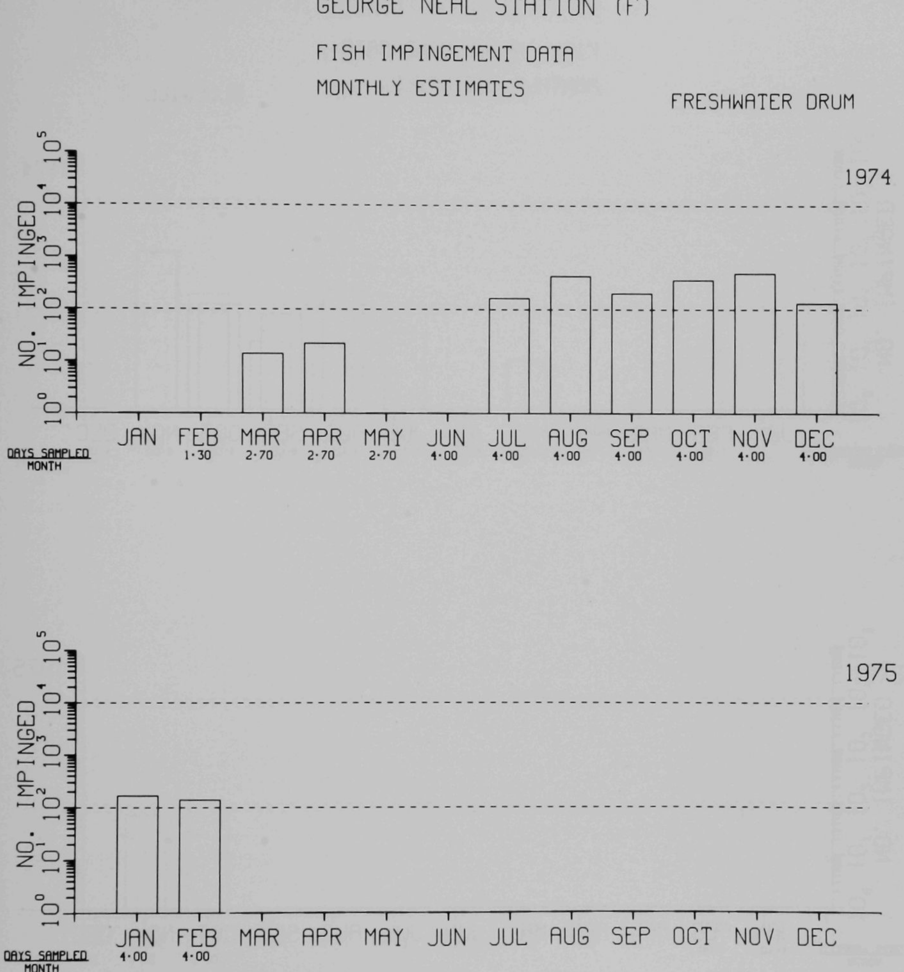


Fig. H3. Impingement Estimates.

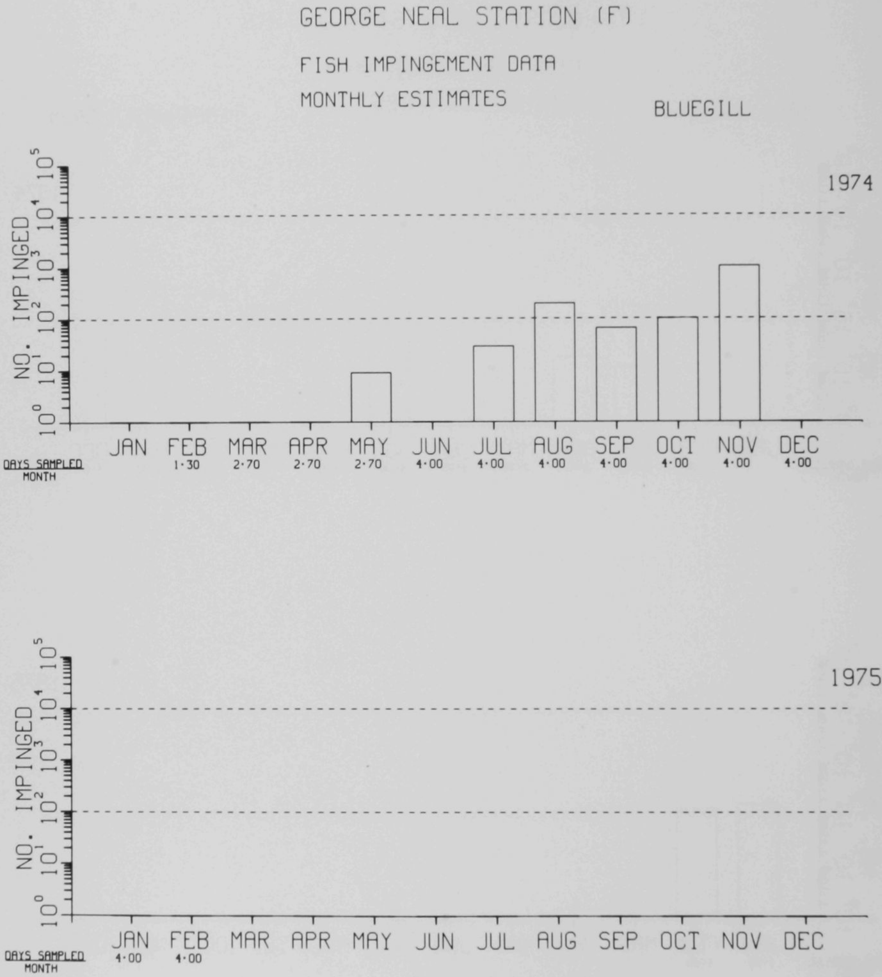
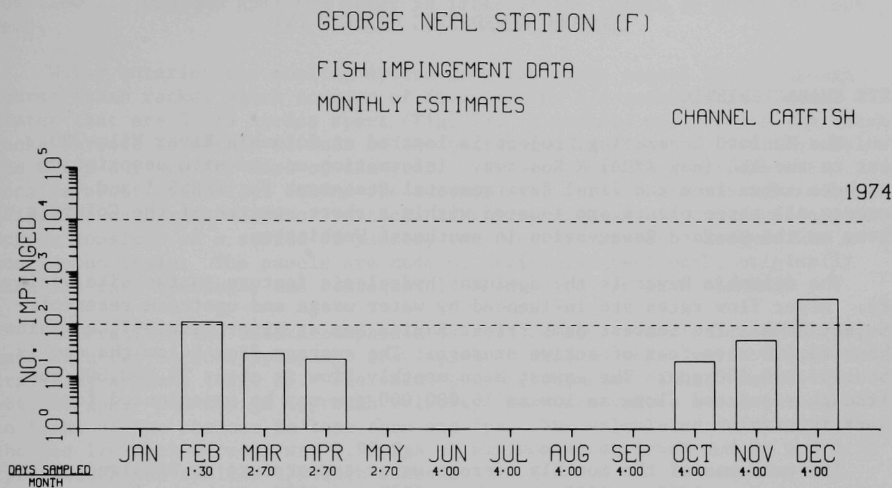


Fig. H4. Impingement Estimates.



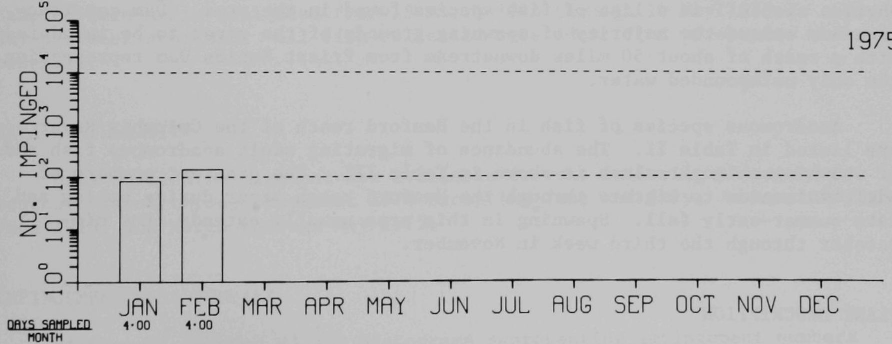


Fig. H5. Impingement Estimates.

HANFORD GENERATING PROJECT (N)

SITE CHARACTERISTICS

The Hanford Generating Project is located at Columbia River Mile 380, next to the AEC (now ERDA) N Reactor. Information on the site description has been taken from the Final Environmental Statement for WPPSS 1 and 4,[1] because all three plants are located within a short stretch of the Columbia River on the Hanford Reservation in southeast Washington.

The Columbia River is the dominant hydrologic feature in the site vicinity. River flow rates are influenced by water usage and upstream reservoir-project dams. The nearest dam, Priest Rapids Dam at River Mile 397, contains about 45,000 acre-feet of active storage. The average flow below the dam is about 54,000,000 gpm. The lowest mean monthly flow is about 28,000,000 gpm, although regulated flows as low as 16,000,000 gpm may be experienced for short intervals.

The extremes of the monthly average water temperature at Richland, Washington, from 1965 to 1973 were about 35°F and 68°F, with the low occurring in February and the high in August. Impoundment has created a shift in the seasonal temperature cycle, but it has not significantly changed the annual average water temperature.

The river bottom is generally cobblestone and gravel substrate. This characteristic and turbulent flow rates prevent the establishment of macrophytes. Table I is a list of fish species found in the area. Dam construction has caused the majority of spawning grounds of the river to be inundated, with a reach of about 50 miles downstream from Priest Rapids Dam representing the only unimpounded water.

Anadromous species of fish in the Hanford reach of the Columbia River are listed in Table II. The abundance of migrating adult anadromous fish and of spawning chinook salmon is shown in Table III. The greatest numbers of adult salmonids to migrate through the Hanford reach occur during spring and late summer-early fall. Spawning in this area usually extends from mid-October through the third week in November.

PLANT DESCRIPTION

The Hanford Generating Project uses a production reactor with once-through cooling, and generates 700 MWe.

INTAKE DESIGN AND OPERATION

The pumphouse is a typical bankside, shoreline installation (Fig. 1).[2] The site for the intake structure was excavated to about ten feet below the normal river bottom and extends into the river for 75 to 125 feet. At design low flow (16,000,000 gpm) the water in front of the intake is about 20 feet deep.

Water entering the cooling system from the river passes first through coarse trash racks, which consist of five-inch by 1/2-inch vertical steel grates that are 3-1/4 inches apart (Fig. 2). A curtain wall behind the trash racks extends to within 22 feet of the bottom and is three to five feet below the water surface for most of the year. Vertical traveling screens are located about eight feet behind the curtain wall. There are six screen bays (Fig. 3), each with a row of vertical traveling screens. Each traveling screen consists of a series of panels, ten feet by two feet, hinged into a continuous chain. The panels are made of stainless-steel mesh, originally with 1/4-inch openings, and subsequently changed to 1/8-inch openings.

Internally, the intake pumphouse is divided into two replicate halves, each with two 141,000-gpm pumps drawing water through three vertical rows of traveling screens (Fig. 3). The total pumping capacity of both halves is 564,000 gpm. The design approach velocity (measured values are not available) in front of the screens is less than one fps. The calculated velocity through the old 1/4-inch screens was 1.95 fps at minimum water level and is now 2.36 fps through the smaller 1/8-inch screens.

IMPINGEMENT SAMPLING

Traveling-screen wash samples were obtained on odd-numbered days throughout most of the study from 28 March 1973 through 19 April 1974. Samples were collected daily during the workweek from 21 April 1974 through 5 June 1974. Samples were again collected from 18 March 1975 through 10 May 1975 on a five-day-per-week schedule. All fish collected were identified to species whenever possible.

DATA AVAILABILITY

Data on fish impingement are available for the following years and months: March through December 1973 excepting June and July, January through June 1974, and March through May 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H3 are histograms representing impingement numbers for the available data. The data have been grouped into "salmonids" and "non-salmonids" as well as all species. Table IV is a summary of the available data.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

The Hanford Generating Project does not employ any additional features for minimizing impingement; however, the lowering of stoplogs to deter chinook fry was examined. The results indicated that the number of fish impinged on either side of the intake depends in part on the number of pumps operating. Even though this may have masked any attempt to determine the effect of lowering the stoplogs, the data suggest that lowering the stoplogs may not have had an effect on the number of chinook fry impinged, and that the fish are either lower in the water column than expected or tend to sound and pass the barrier.[3]

REFERENCES

1. "Final Environmental Statement, WPPSS Nuclear Projects 1 and 4." USNRC Office of Nuclear Reactor Regulation. Docket Nos. 50-460 and 50-513. March 1975.

2. R. H. Gray et al. "A Study of Fish Impingement and Screen Passage at Hanford Generating Project--A Progress Report." Battelle/Pacific Northwest Laboratory, Richland, Washington. January 1975.

3. T. L. Page et al. "Report on Impingement Studies Conducted at the Hanford Generating Project--March and April 1975." Battelle/Pacific Northwest Laboratory, Richland, Washington. June 1975.

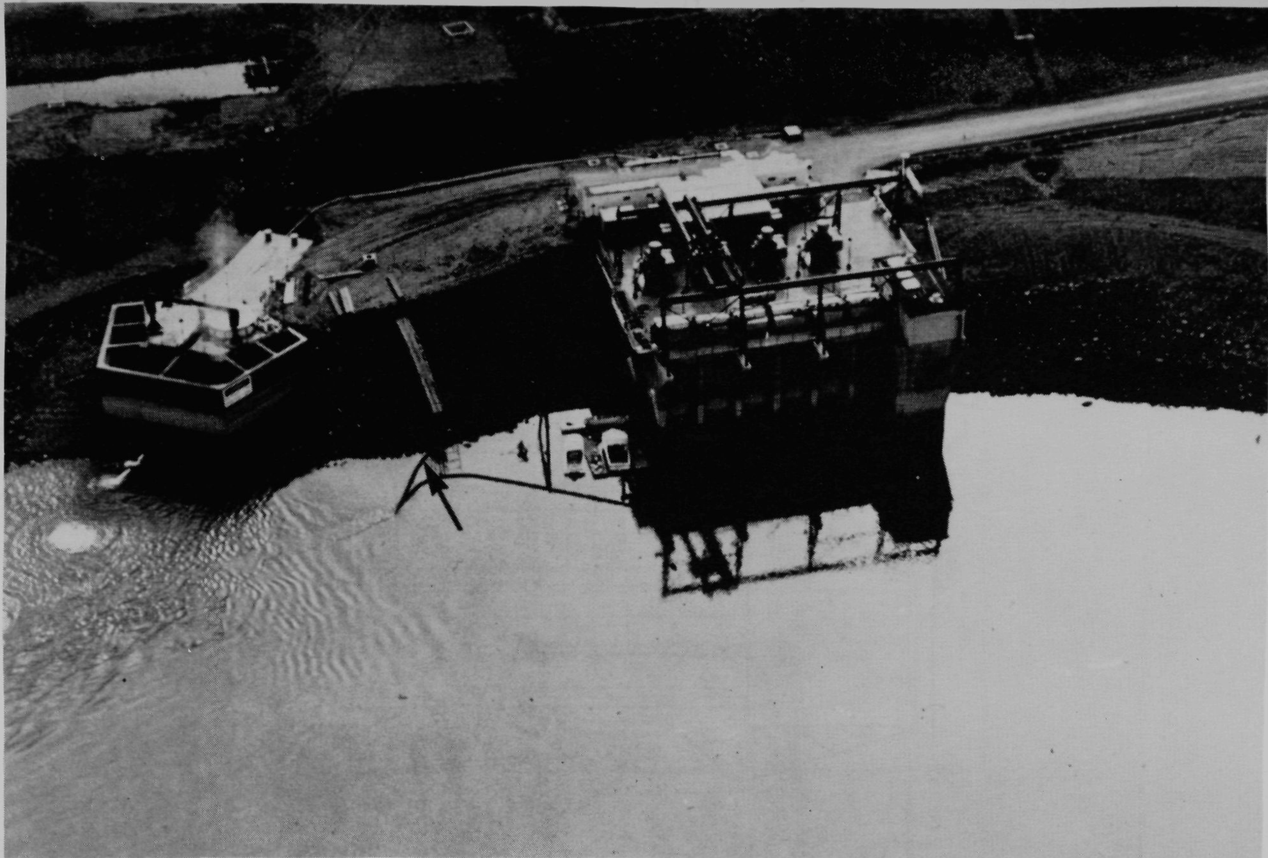


Fig. 1. Intake (right) and Outfall (left). Arrow Designates Trash-Return Pipe.

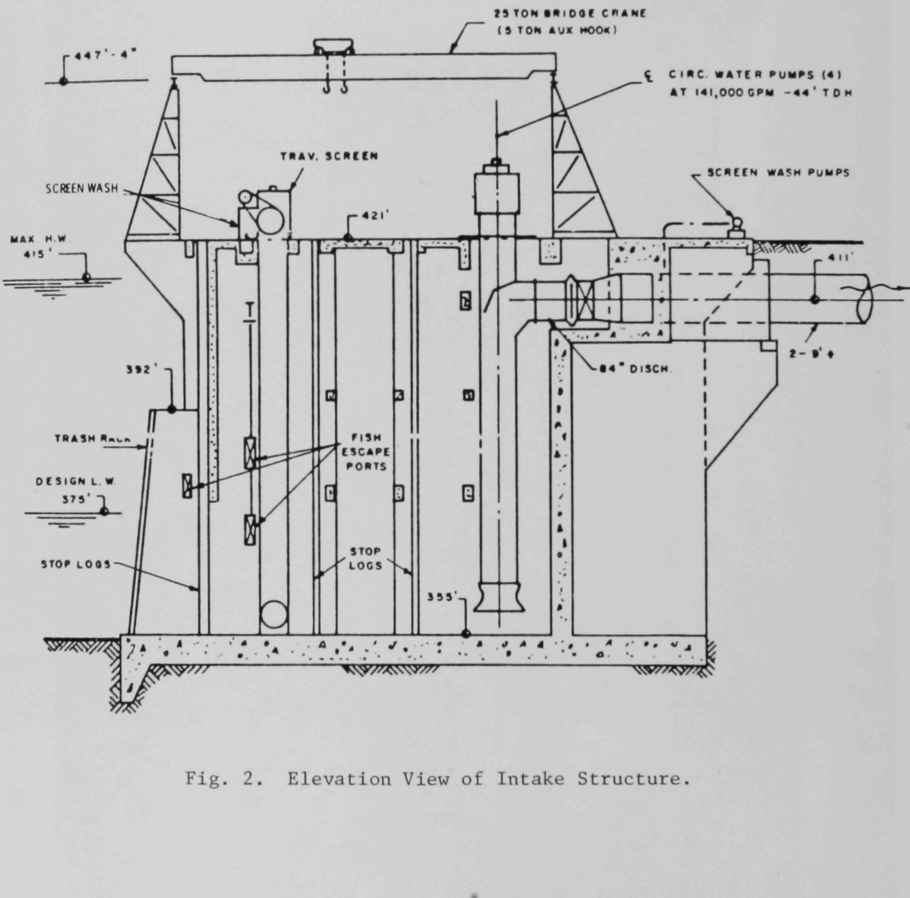


Fig. 2. Elevation View of Intake Structure.

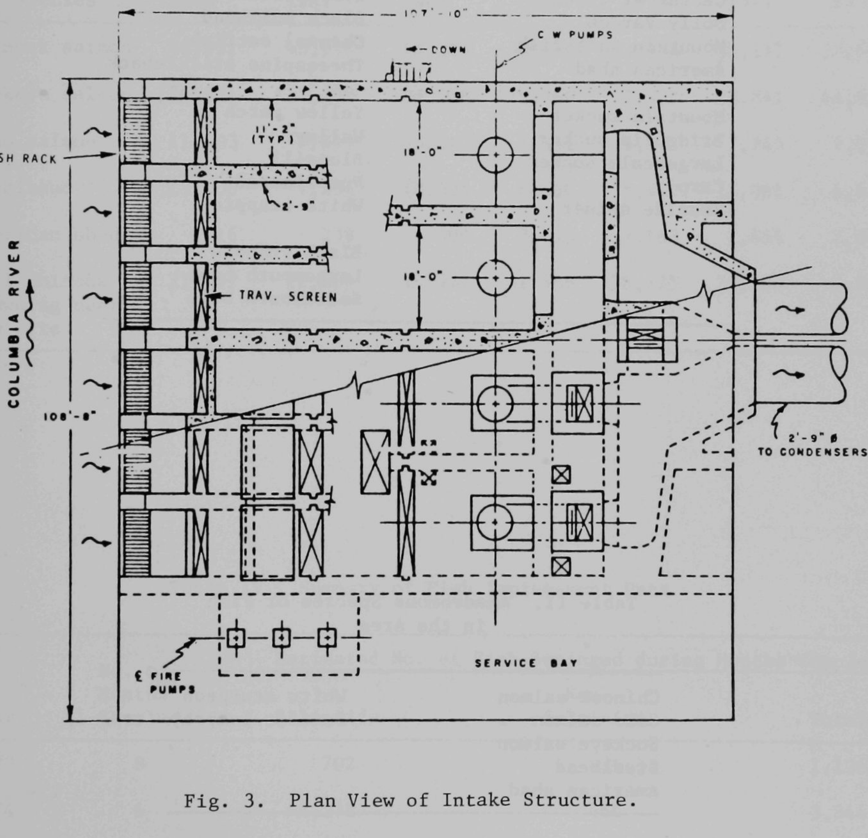


Fig. 3. Plan View of Intake Structure.

Table I. Fishes Found in the Area

Pacific lamprey	Northern squawfish
White sturgeon	Chiselmouth
Chinook salmon	Peamouth
Sockeye salmon	Blacknose dace
Coho salmon	Longnose dace
Steelhead	Speckled dace
Cutthroat trout	Brown bullhead
Dolly Varden	Black bullhead
Mountain whitefish	Channel catfish
American shad	Threespine stickleback
Mountain sucker	Yellow perch
Bridgelip sucker	Walleye
Largescale sucker	Bluegill
Carp	Pumpkinseed
Redside shiner	White crappie
	Black crappie
	Largemouth bass
	Smallmouth bass

Table II. Anadromous Species of Fish in the Area

Chinook salmon	White sturgeon
Coho salmon	Pacific lamprey
Sockeye salmon	
Steelhead	
American shad	

Table III. Adult Anadromous Fish Passage at Priest Rápids Dam and Estimated Chinook Salmon Spawning near the Site

Species	Year						
	1966	1967	1968	1969	1970	1971	1972
Chinook salmon	66,951	48,918	48,314	40,786	43,934	36,117	32,639
Sockeye salmon	170,071	123,786	108,308	39,240	77,422	73,841	44,957
Coho salmon	11,903	8,879	13,212	1,351	4,971	7,743	5,293
Steelhead	13,006	7,354	10,524	6,650	5,442	11,061	6,437
American shad	716	239	300	3,440	7,163	1,454	2,370
Fall chinook spawning near the site	21,707	22,869	24,920	31,556	26,775	25,200	6,132

Table IV. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled		
		Salmonids	Non-Salmonids	Total
1973	8	702	434	1,136
1974	6	3,378	466	3,844
1975	3	57,624	4,894	62,518

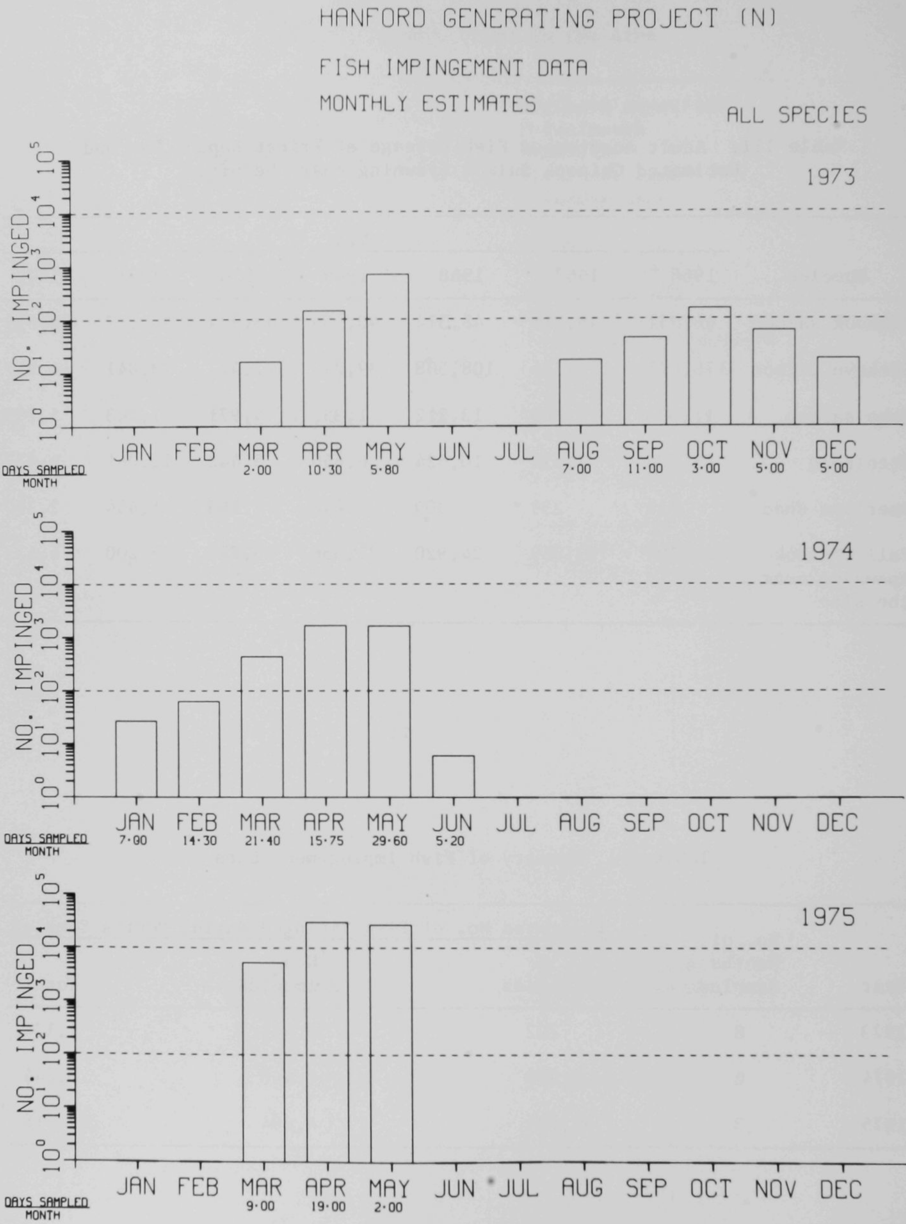


Fig. H1. Impingement Estimates.

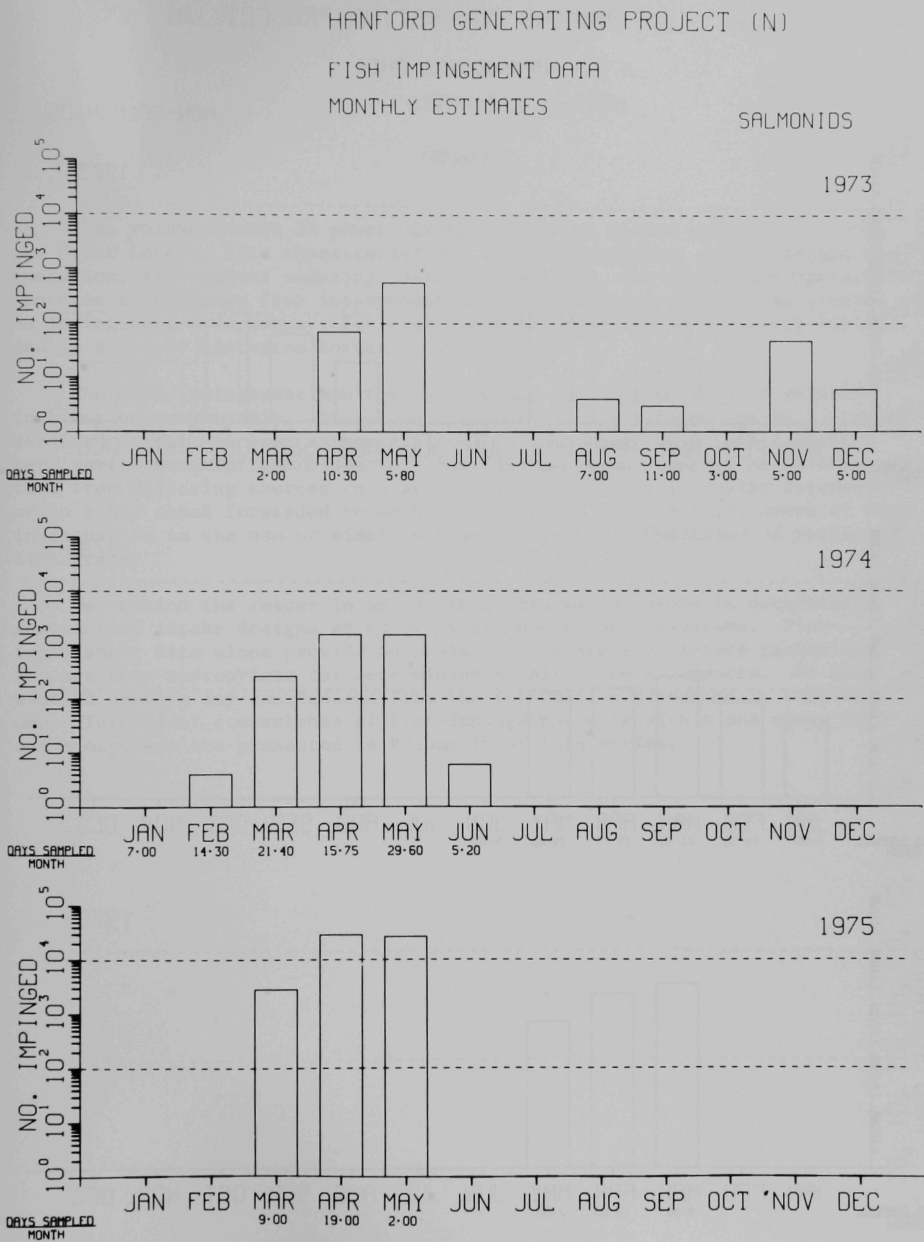


Fig. H2. Impingement Estimates.

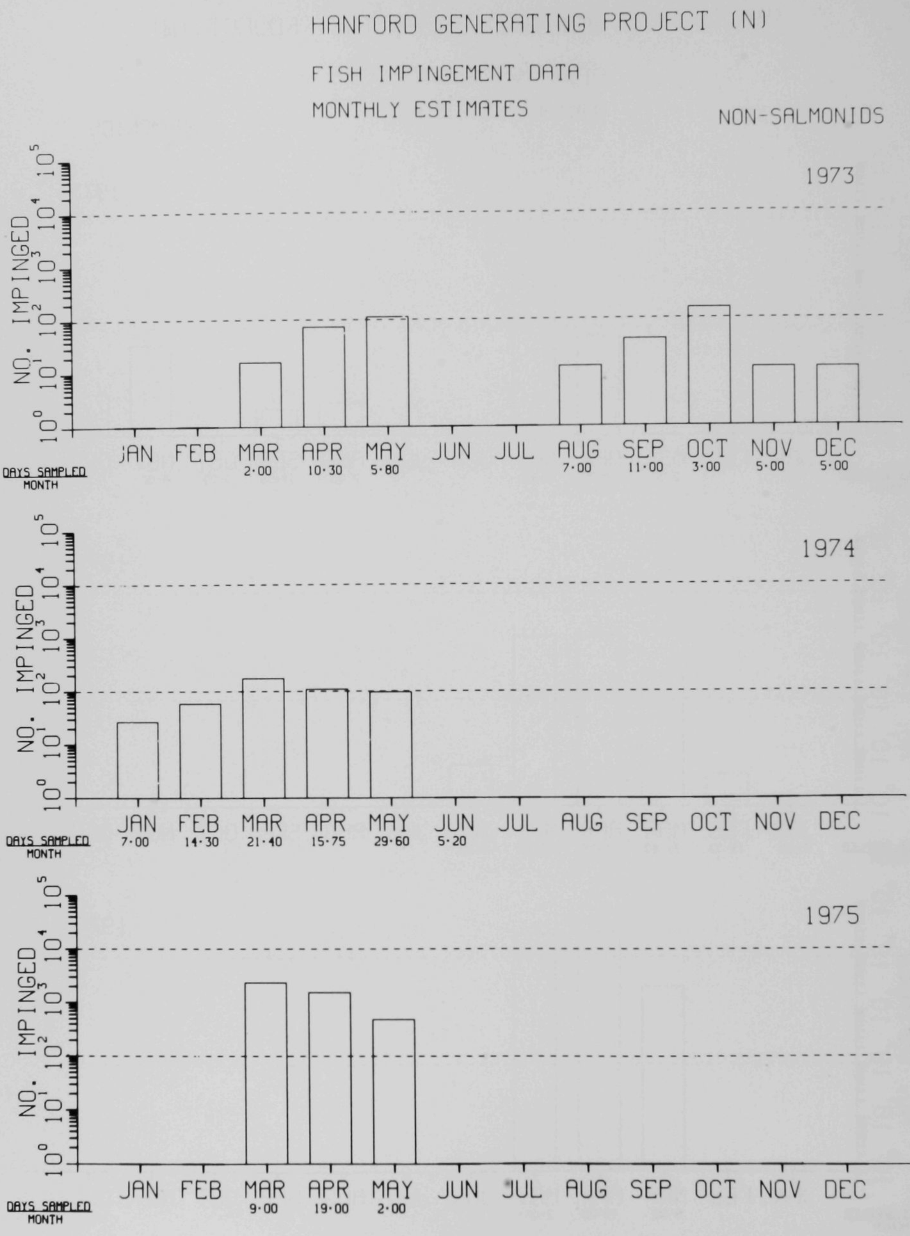


Fig. H3. Impingement Estimates.

SUMMARY

This volume covers 33 power plants located on inland waters other than the Great Lakes. Site characteristics, plant description, intake design and operation, impingement sampling, data availability, and design and operational features to minimize fish impingement are described for each of the plants. An impingement-data summary for each plant is presented in a summary table and in a yearly histogram format in each report.

The fish-impingement monitoring programs and availability of related information vary widely. Therefore, presentation of information in a standardized format has been rather difficult. The amount of detail presented here varies greatly from plant to plant because we had to rely on information from differing sources such as that available only in public documents or in other cases forwarded to us by the utility. We are fully aware of the inadequacies in the use of simple extrapolation for preparation of yearly histograms.

We caution the reader in use of this information alone in determining adequacy of intake designs or severity of impacts on ecosystems. Fish-impingement data alone provide no basis for decisions on intake technology nor are they appropriate for determining significance of impacts. We have avoided drawing any conclusions from the information presented in this volume. Interplant comparisons of fish-impingement data within and among various ecosystems are presented in Volume IV of this series.

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